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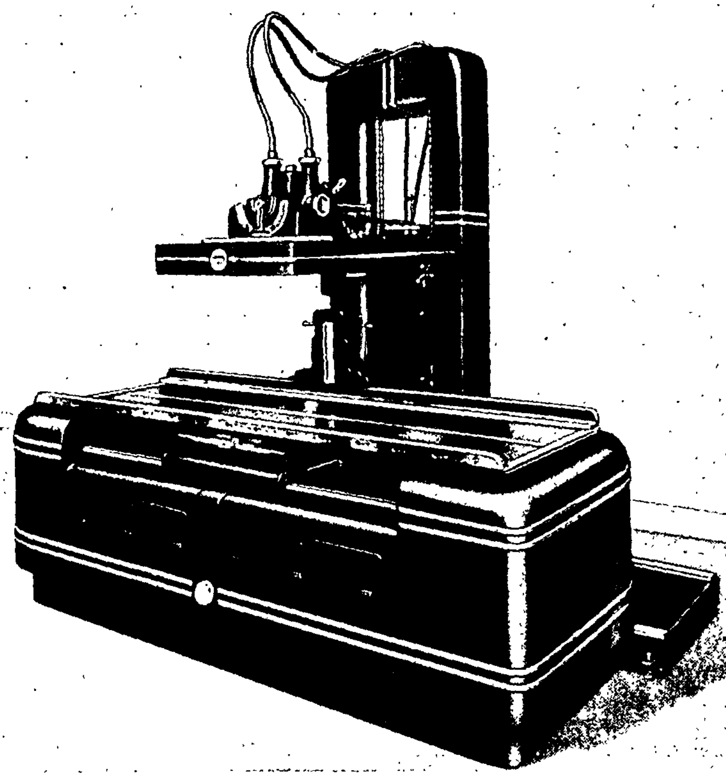

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EXTRA-ALIMENTARY CAUSES OF ALIMENTARY FILLING DEFECTS[1]

By MAXIMILIAN J. HUBENY, M.D., F.A.C.R., F.A.C.P., *Chicago*

Director of Department of Roentgenology of the Cook County Hospital

THE object of scientific medicine is to recognize disease processes early, which can be attained only by the intelligent application of precise methods. Biochemistry is an outstanding example, its usefulness being ever-expanding. It is interesting to deal with changes before they become ponderous, before they have attained weight and dimension.

The roentgenological method of examining the gastro-intestinal tract enables one to appreciate not only organic changes, but indirect signs, such as subtractions from or additions to silhouettes, spasms, fixations, redundancies, points of tenderness, etc.

In the phylogenetic development of the gut tube, there has come about a radical subdivision in morphology, physiology, and function; these subdivisions are intimately related and an affection of one tends to disorganize all.

The gall bladder, the liver, the pancreas, and the stomach are embryologically, anatomically, physiologically, and pathologically closely related and should be considered as one physiologic system. Because of the continuity and contiguity of these numerous structures it is quite necessary to recognize filling defects as of pathologic and non-pathologic significance. The filling defect is the basic roentgenological sign of morbidity and, because of simulants, great care should be exercised in its proper recognition.

Irregularities in outline are also important roentgenological manifestations, whether they be due to additions to or subtractions from the normal contour. Filling defects are subtractions, and these may be (*a*) first, organic; second, spasmodic; third, physiologic; (*b*) intra-alimentary or extra-alimentary.

Errors in technic are responsible for some apparent defects. Among the most frequent is the neglect of eliminating pressure of the spine on the gastric shadow because of failure to elevate the chest and hips of the patient. Assuming that proper technic is practised, this source of mistakes can readily be excluded.

The genuineness of a filling defect is portrayed by its persistence under all conditions during fluoroscopic examination, its unaltered position and contour after massage, its constance upon all films and successive examinations, and the lack of obliteration after the administration of antispasmodics. The permanence and actuality of a filling defect cannot always be determined by taking a few roentgenograms alone: occasionally many films are necessary. The fluoroscopic examination

[1] This is one of a series of papers contributed by friends and former pupils of I. Seth Hirsch, M.D.

is often invaluable, for the shadow can be observed at various angles and positions and with the application of manipulation and pressure, and with the effect of gravity an obscure point may become quite perceptible. Some absence of peristalsis will assist in differentiation.

The filling defect may correspond to a palpable mass, for in occasional instances tumor masses that elude detection at the physical examination are felt by the roentgenologist. Unevenness of outline and lack of symmetry are rather constant in true filling defects. Abdominal rigidity and tension, pressure of a deformed costal arch, ascites, ovarian cyst, or pregnancy may produce irregularities in the outline of the alimentary canal.

Faulty media in which the barium is not evenly distributed may be misleading. Gas in the colon or fecal matter in the adjacent bowel also may cause indentations; however, palpatory shifting will help to identify these. Abnormal ligaments, peritoneal adhesions or membranes may produce filling defects. Mention will first be made of non-pathologic filling defects.

Commencing at the oral opening, the first defect noticeable may be the esophageal indentation produced by the aortic arch, which is liable to be accentuated by the presence of aneurysm. The next irregularity is produced by the anatomic relation of the esophageal opening in the fornix of the stomach, accentuated or moderated by the angle of entrance. Sometimes the diaphragm produces an irregularity which is caused by the apposition of the cardia and the muscular interdigitations of the diaphragm. This has been noted especially in cases in which tight corsets have been worn.

The spleen is the next offender, the shadow produced being quite characteristic. The size and shape of this indentation will vary according to the size and shape of the spleen, the type of stomach, etc., along the greater curvature, and, in close approximation to the splenic defect we often have a gastric irregularity due to a gas-distended or feces-filled splenic flexure. Sometimes the lesser curvature presents a conformation due to large psoas muscles, and the usual exhibition associated with the abdominal aorta. Confirmatory diagnosis of aneurysm of the abdominal aorta can occasionally be made because undue gastric pulsation can be detected fluoroscopically. A physiologic kyphotic or lordotic spine may produce simulants of defects. The gastric shadow is sometimes affected by the pressure of the transverse colon or a filled hepatic flexure which may impinge on the pyloric region.

In some instances the gall bladder, either pathologic or non-pathologic, but especially the former, may subtract from the area of the pyloric region, particularly along the greater curvature. The third portion of the duodenum may show irregularities, as it passes over the spine. It often happens that a concentric arrangement of portions of the jejunum or ileum, especially the latter, will cause apparent filling defects of the adjacent bowels, especially misleading when a non-visualized mass is contained in the lumen of the intestines.

The terminal loops of the ileum are many times lifted above the iliopectineal lines by a filled cecum, sigmoid, and rectum or a distended bladder. The iliopectineal eminence often leaves its impress on the cecum or ascending colon as well as distorting the region of the junction of the ileac and pelvic colons.

It is quite impossible to embrace all or most of the phenomena in this brief outline, but the aforementioned conditions typify the usual probable sources of confusion, which can readily be recognized if anticipated. Among some of the pathologic conditions which produce filling defects are carcinoma, lymphosarcoma, splenomyelogenous leukemia, splenic leukemia, syphilis, varicosities, adhesions, and benign tumors such as uterine fibroids and ovarian cysts.

Since roentgenology is a branch of medicine, it should not confine itself to descriptive methods. All the manifestations observed should be transcribed into clinical and pathologic entities. Consequently the roentgenologist should require

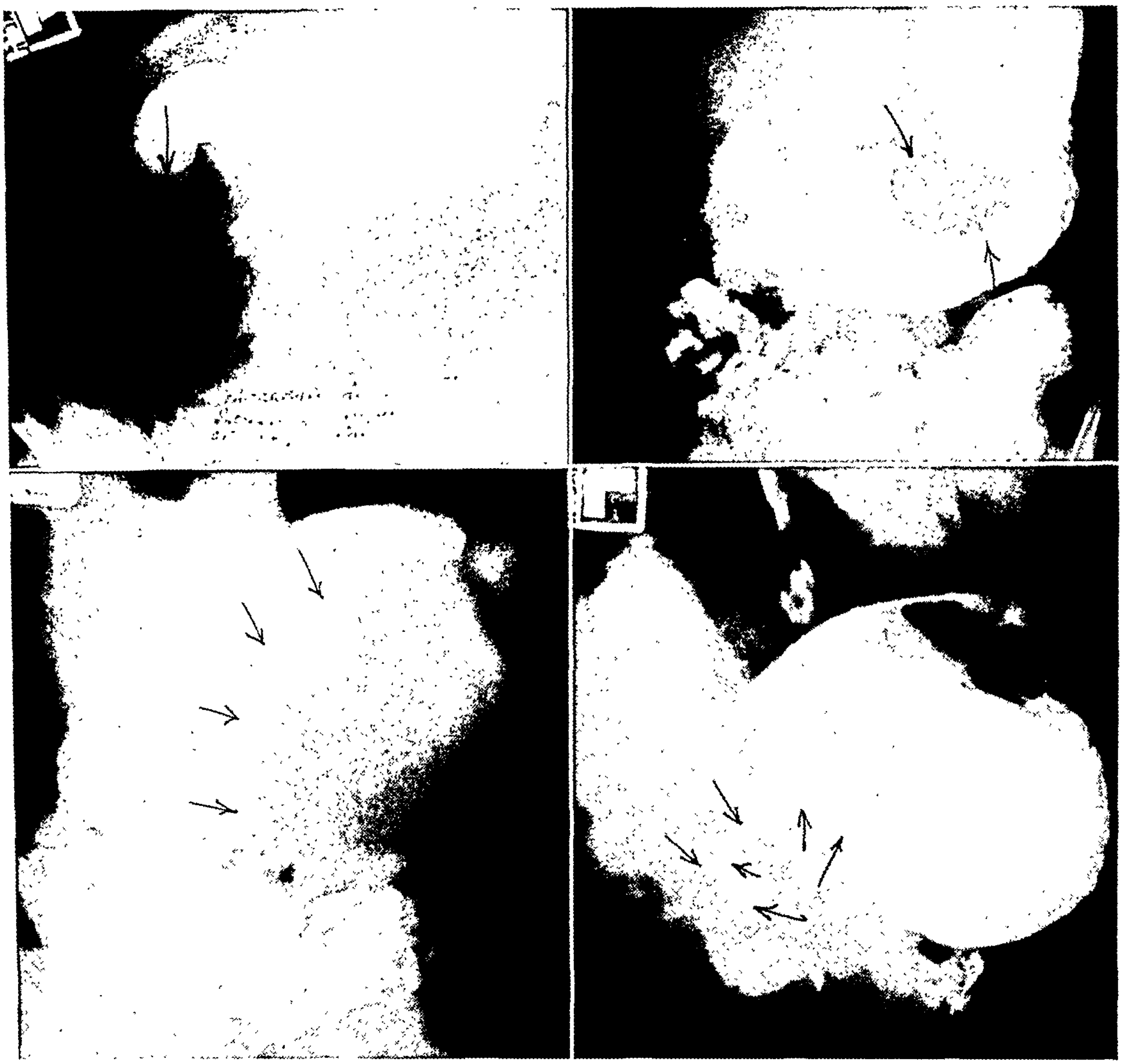
all the pertinent data and subsequently should follow up the case to the point of finality. A tentative diagnosis is unsatisfactory.

With this premise in mind, the subjoined citations are informative and the work-ups consistently thorough.

Case 1, B. K., female, aged 27 years.

History.—This patient was admitted to the Cook County Hospital on Aug. 5, 1937, complaining of epigastric pain and vomiting of three days' duration. This began as a sudden pain in her back, radiating to both lower quadrants. Vomiting, enemas, and bowel movements gave no relief. Pain was continuous and of increasing intensity up until the time of entrance.

Physical examination revealed a distended abdomen, with tenderness and resistance in both lower quadrants. Peristaltic sounds were absent. There was rebound tenderness noted at McBurney's point.



Case 1 (*upper left*). B. K., pancreatic abscess with sloughing and necrosis of the body and the tail.
Case 2 (*upper right*). L. D., cyst in tail of pancreas.
Case 3 (*lower left*). A. Z., probably benign pancreatic cyst.
Case 4 (*lower right*). M. B., carcinoma in head of pancreas; gall bladder greatly distended.

Laboratory Findings.—On Aug. 15, the red blood cells were 3,370,000, white blood cells, 22,750, polymorphonuclears 79, eo-

sinophils 1, basophils 1, lymphocytes, 14, monocytes, 5.

On Aug. 20, red blood cells were 3,070,000, white blood cells 11,650.

Urine was negative for albumen and sugar.

X-ray examination showed dilatation of the stomach by retained gastric contents. There was an extrinsic mass, causing pressure on the pylorus and the second portion of the duodenum, resulting in a high partial obstruction. Pancreatic tumor or cyst as well as mesenteric cyst had to be considered.

Clinical Diagnosis.—Acute bilateral salpingitis and pelvic peritonitis at first. Then considered were (1) infected pancreatic cyst and (2) infected horseshoe kidney.

Course.—The abdomen remained tender and distended and on Aug. 14, 1937, a mass was palpated in the epigastrium. The temperature was elevated, fluctuating from 100 to 103°. Exploratory operation was done on Aug. 27, 1937, and 3,000 c.c. of foul pus were drained from a pancreatic abscess. The patient expired on Aug. 28, 1937.

Anatomic Diagnosis.—(1) Pancreatic abscess, with sloughing and necrosis of the body and tail of the pancreas; (2) severe infectious hyperplasia of the spleen; (3) cloudy swelling and parenchymatous degeneration of the heart, liver, and kidneys; (4) recent laparotomy wound; (5) fat necrosis of the greater omentum, mesentery, and gastrocolic ligament; (6) cholelithiasis; (7) chronic salpingitis.

Case 2, L. D., male, aged 35 years.

History.—This patient was admitted to the hospital on June 13, 1938, complaining of epigastric pain of two months' duration. He was perfectly well up until two months previously, when he developed epigastric pain, which had its onset about 2 A.M. The pain was hunger-like in character and lasted a few minutes; relieved by milk or an egg-nog. This pain also occurred during the day from one to two hours after meals and was relieved by milk.

The past history was essentially negative.

Physical examination revealed a well developed, well nourished, white male about 35 years of age who did not appear acutely ill. The essential findings were as follows: Head—Right pupil larger than the left; both reacted to light and accommodation. Neck—Essentially negative. Chest—Lungs clear; heart within normal findings. Abdomen, genitalia, extremities, and reflexes were essentially negative.

The impression was of peptic ulcer with hyperchlorhydria. It was necessary to rule out a carcinoma of the stomach.

Course and Work-up.—First barium meal on June 10, 1938, taken through the Admitting Department, revealed a filling defect in the pars cardia. The second barium meal, on June 15, revealed a large area of incomplete filling in the stomach indicative of an intragastric newgrowth, probably carcinoma.

Blood Examination.—Hemoglobin 70 per cent; red blood cells 4,500,000; white blood cells 7,000.

Stomach Contents.—The small meal showed free acid 0°; total acid 12°; combined acid 12°; mucus III; chemical blood. The feces were negative for blood. The urine was essentially negative. The patient continued to have post-prandial pain, and an exploratory laparotomy was advised.

He was explored on June 25, 1938, and a pancreatic cyst was found in the tail of the pancreas, displacing the stomach anteriorly. A pancreatico-cholecystostomy was done. The patient made an uneventful post-operative recovery and was discharged July 15, 1938.

Case 3, A. Z., male, aged 78 years.

History.—This patient was admitted to the hospital on June 8, 1937, complaining of pain and swelling of the abdomen for one year. He spoke Bohemian and it was difficult to elicit a history. It appeared he was apparently well until one year previously, when he began to notice a swelling of his abdomen. This progressively became larger and, as it did so, it also became very painful. In the last few weeks before ad-

mission he had become markedly constipated.

Physical Examination.—Temperature 98°; respirations 28; blood pressure 170/90.

Essential Findings.—Chest was hyperresonant and there were a few expiratory râles at both pulmonary bases. The heart was slightly enlarged and the tones were distant. There was a large mass, the size of a grapefruit, in the left upper quadrant of the abdomen. The prostate gland was somewhat enlarged. Differential diagnosis had to be made of (1) pseudo-pancreatic cyst; (2) retroperitoneal tumor, or (3) intragastric tumor.

Course and Work-up.—The urine was essentially negative. Stools were positive for chemical blood. Blood examination showed hemoglobin 65 per cent; red blood cells 4,380,000; white blood cells 7,550. The differential count was as follows: polymorphonuclear neutrophiles 60 per cent; polymorphonuclear eosinophils none; polymorphonuclear basophils none; lymphocytes 14 per cent; monocytes 6 per cent; stab cells 17 per cent; undifferentiated 3 per cent.

On a flat film of the abdomen, taken on June 9, there appeared to be a large mass in the left side of the abdomen. After a barium enema (June 15), a large extrinsic mass depressing the splenic flexure of the colon was seen. After a barium meal (June 18), a huge extrinsic mass, displacing the stomach upward and to the right, with pressure defect, was observed.

The genito-urinary work-up was essentially negative. A diagnosis of benign pancreatic cyst was made and an exploratory laparotomy suggested, but the patient refused surgery and was discharged on July 2, 1937.

Case 4, M. B., male, aged 49 years.

History.—This patient was admitted to the hospital on Oct. 4, 1937, complaining of loss of weight, polyurea, and a ferocious appetite. He had lost 50 pounds in weight.

Physical Examination.—There were no unusual findings. The urine contained sugar, diacetic acid, and acetone, and the diagnosis of diabetes mellitus was made. The patient was placed on management, and discharged under care of the diabetic clinic. He required protamine insulin 73 units daily.

This patient was admitted the second time to the hospital on Dec. 13, 1937, on which occasion he had jaundice of ten days' duration. Epigastric pain had been present for four weeks. Physical examination disclosed a nodular liver, tender and enlarged. The previous diagnosis of diabetes mellitus was reaffirmed and the additional consideration of carcinoma of the stomach added. He complained of "terrible backache" up the spine to the level of the shoulder blades. Differential diagnosis then included tumor of the head of the pancreas. Carcinoma of the bile ducts and common duct stone were also considered. Transfer to surgery was agreed upon.

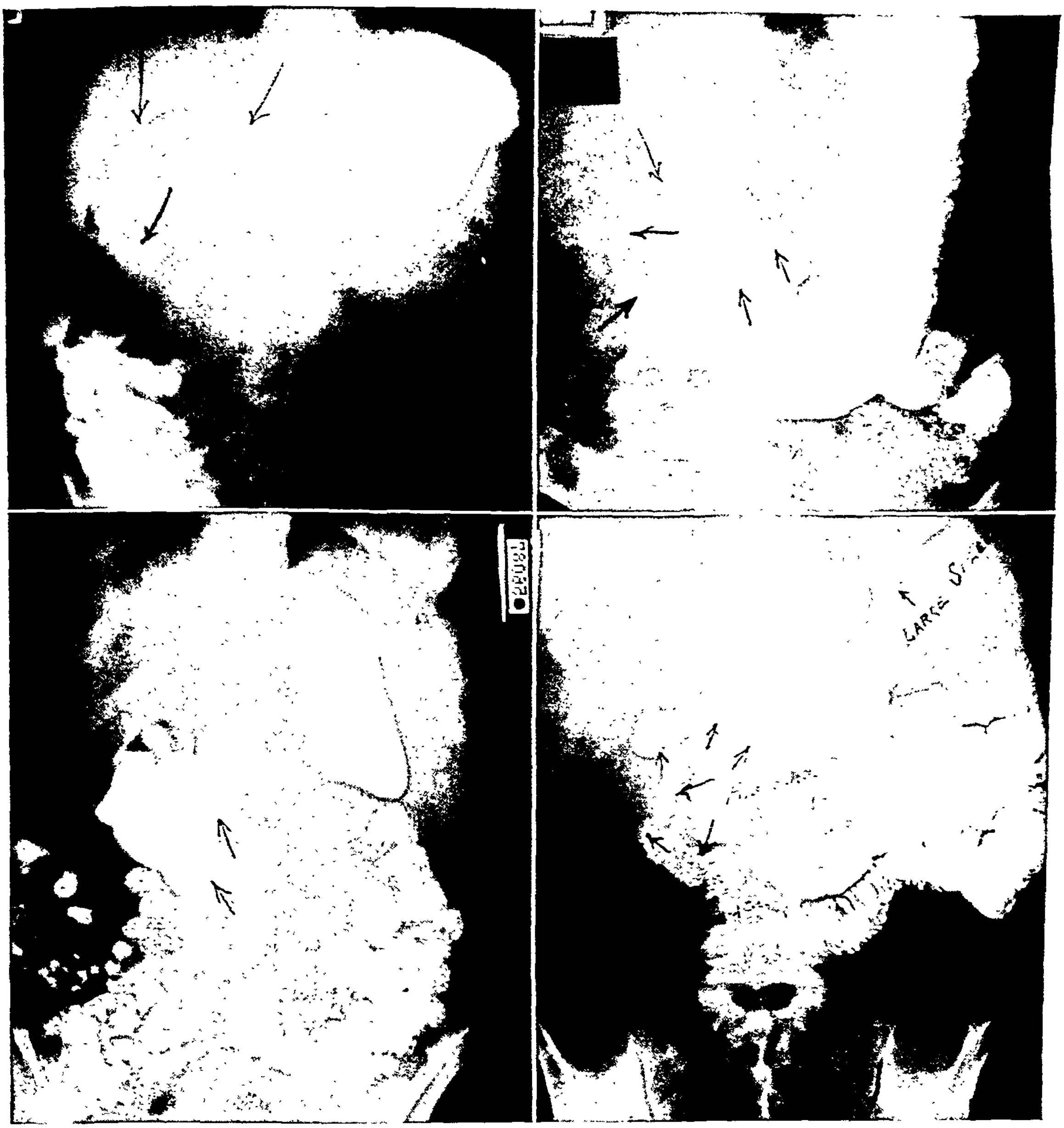
At operation, "a carcinoma of the head of the pancreas was found. There was a huge mass covering the entire retroperitoneal area, with metastases to the liver. There was bile-stained fluid free in the peritoneal cavity. The gall bladder was greatly distended with bile." The operation done was cholecystogastrostomy, over a catheter. Following the operation the patient did not do so well, quickly developed a congestion of both lungs, was given oxygen and the usual therapy, but died on the second post-operative day.

Case 5, F. R., male, aged 30 years.

History.—This patient was admitted to the hospital on Oct. 22, 1931, complaining of a sudden severe pain in the epigastrium. The onset was without any premonition, while he was working—hanging and pasting paper. He compared the pain to a "sudden blow in his abdomen," and it lasted about forty-five minutes. Five days later he began to notice a swelling in his abdomen. This progressively became larger until the day of admission.

Physical Examination.—Temperature 97°; pulse 74; respirations 20; blood pressure 112/68. The patient was a white male, of Latin race, who did not appear

acutely ill. There was present a large mass in the abdomen—fairly firm, movable up and down. There was slight pain on pressure. Pulsation of the aorta was transmitted to the mass.



Case 5 (*upper left*). F. R., adenocarcinoma originating from aberrant-pancreatic tissue.
Case 6 (*upper right*). J. S., carcinoma of whole head and body of pancreas.
Case 7 (*lower left*). N. M., carcinoma of body of pancreas with cystic degeneration; spleen enlarged.
Case 8 (*lower right*). G. L., large gall bladder compressing stomach; common duct 4 cm. in diameter.

The heart was enlarged; presystolic thrill over the precardial area; diastolic and presystolic murmurs over the apex.

It was necessary to make a differential diagnosis between pancreatic cyst and rheumatic heart disease.

Course and Work-up.—The urine was negative. Blood chemistry showed urea nitrogen 13.4; blood sugar 67.0; icteric index 4.00; blood examination: red blood cells 4,759,000; white blood cells 8,500.

The barium meal revealed no apparent pathology in the stomach and duodenum. Stomach contents showed free acid 108, total acid 122.

The mass remained about the same size while the patient remained in the ward, and an exploratory laparotomy was advised. He was operated upon on Nov. 25, 1931, and a large aggregation of omentum was found over the pancreas, also a large cyst fluctuant posteriorly to the pancreas. Due to mechanical difficulty and the precarious position of the mass, no attempt was made to incise or isolate it. A barium meal (Nov. 18), one week prior to the operation, showed that the second and third portions of the duodenum formed a large "C" loop with some compression on the second portion resembling an enlargement of the head of the pancreas. The patient had a stormy convalescence and was finally discharged Jan. 21, 1932.

He was re-admitted to the hospital on Feb. 3, 1932, complaining of dyspnea on exertion, swelling of the ankles, and heaviness and fullness in the right upper quadrant.

Course and Work-up.—The stools were positive for blood. Blood chemistry—urea nitrogen 9.80, sugar 85.0. The blood Wassermann test was negative. A flat film of the chest revealed the mitral type of heart, showing moderate enlargement with passive congestion. EKG was negative. His condition progressively became worse until he expired on March 13, 1932.

Autopsy Findings.—Adenocarcinoma originating from aberrant pancreatic tissue and perforating into the third portion of the duodenum; metastasis to the liver; fibroplastic calcific deformity of the mitral valve with marked stenosis of the ostium; slight hypertrophy of the heart, with anemia and parenchymatous degeneration of the myocardium; anemia of the liver, spleen, and kidneys; marked edema of the lungs; bloody intestinal contents; slight edema of the legs.

Case 6, J. S., colored, aged 50 years.

History and Physical Examination.—This patient entered the hospital on Sept. 6, 1938, complaining essentially of pain in the epigastrium of two and one-half months' duration. There had been a loss of 32 pounds in weight; yellow discoloration of eyes and skin. Pruritus and nosebleeds, one month. Physical examination revealed a palpable hard globular mass in the right upper quadrant.

Course and Work-up.—the urine showed sugar 3 plus; bile plus; no urobilinogen repeatedly. Hemoglobin 85 per cent; red blood cells 4,840,000; white blood cells 6,650. The Ewald meal 25 free, 46 total HCl. Stools—3 plus blood repeatedly; negative for bile repeatedly. Blood chemistry, total protein 8.38; albumen 5.52; globulin 2.83; cholesterol 212; calcium 9.9; phosphorus 7.4. Wassermann test was negative. Icteric index, 99 Sept. 3, 1938; 150 Sept. 11, 1938. Glucose tolerance test, fasting 75, 166 at 30 minutes, 250 at one hour, and 214 at two hours.

On x-ray examination, the colon filled well, showing no pathology. There was no apparent pathology in the esophagus, stomach, or duodenum fluoroscopically. There was a round, extrinsic pressure defect in the region of the pylorus and the second portion of the duodenum, strongly suspicious of an extrinsic tumor mass, most likely carcinoma of the head of the pancreas.

The patient was operated on, on Sept. 26, 1938, a large tautly distended gall bladder containing 200 c.c. of dark bile being found. The extra-hepatic bile ducts were all distended. The pancreas was tremendously enlarged and nodular. The tumor occupied the whole head and body of the pancreas, pushing forward from below on the stomach and duodenum through the transverse mesocolon.

Pathological Report.—Squamous-cell carcinoma.

Case 7, N. M., colored female, aged 49 years.

History.—This patient was admitted to the hospital on June 16, 1938, her only complaint being persistent, severe, increasing pain in the left upper quadrant,

radiating to her back, for three months. This had no relation to meals or time of the day.

Physical Findings.—Essentially negative except for a firm mass, orange-sized, in the left upper quadrant. This was suspected of being a spleen or kidney tumor.

Course and Work-up.—The urine was negative; stools were negative for blood. Blood: hemoglobin, 75 to 85 per cent; red blood cells, 4,100,000; white blood cells, 2,200 to 3,500; no abnormal cells. Sternal puncture showed normal bone marrow. Blood repeatedly showed no material parasites. Wassermann test was negative. Cholesterol, 128. Pyelography on two occasions showed extrinsic pressure on the medial side of the left kidney.

X-ray examination of the colon on two occasions revealed no intrinsic pathology, but the splenic flexure was low. The heart was enlarged and of aortic configuration. The spine showed slight arthritic changes in the lumbar region. There was a round tumor mass causing extrinsic pressure on the greater curvature of the stomach. Among the possibilities to be considered were tumor or cyst of the pancreas, and, less likely, a mesenteric cyst. The first and second portions of the duodenum were dilated. Fluoroscopically, there was a definite cardiac enlargement.

Biopsy of a skin nodule revealed no evidence of leukemia, or cancer.

The patient was operated on, on Sept. 22, 1938, revealing body of pancreas occupied by a firm tumor 12 × 10 × 8 cm., cystic anteriorly.

Diagnosis: cancer of body of pancreas with cystic degeneration. The spleen was enlarged and soft.

Case 8, G. L., female, aged 42 years.

History.—The patient had been jaundiced for one and one-half years. There was pain in the right upper quadrant and epigastrium. There had been dark urine for 12 months; clay-colored stools for 13 months. Loss of weight, 55 pounds in one year. Swelling of right upper quadrant and epigastrium for eight months.

Physical Examination.—Essentially as follows: marked icterus; liver four fingers below the costal margin; gall bladder palpable.

Course and Work-up.—The blood Wassermann was negative; icteric index 80; Ewald meal free 18, total 47; urine analysis bile 4+; blood 0; urobilinogen 0; stool 4+, blood, one examination.

X-ray Examination.—Flat plate of the gall bladder was negative. Non-visualization of the gall bladder. Stomach, suspicious of head of pancreas; extrinsic pressure.

Surgery revealed a markedly dilated gall bladder compressing the stomach. The common duct dilated three to four centimeters. No tumor was felt in the head of the pancreas. Cholecystogastrostomy was done.

Case 9, C. C., male, aged 53 years.

History.—Patient was admitted to the hospital Feb. 18, 1938, complaining of loss of appetite, loss of 30 pounds of weight, and loss of strength of one month's duration. He had seemed perfectly well up until one month previously when he began to lose his appetite, strength, and weight. He also noticed that his stools had been black for the past week. Otherwise he had no complaints.

Past History.—Patient had had two attacks of severe abdominal pain, one five years previously, the other four years, situated in the epigastrium, knife-like in character, and had to be relieved by a hypodermic. He felt perfectly well the next day after each attack.

Physical examination revealed a well developed, well nourished, white male, who appeared pale. His temperature was 97.4; pulse 112; respirations 26; blood pressure 130/80. Essential findings were as follows: Tongue smooth and glossy; pupils reacted to light and accommodation; neck was negative; lungs clear; heart revealed systolic murmur over the apex. A large nodular mass, rather firm, filled the entire epigastrium; prostate was small and firm; extremities were negative; reflexes were physiological. An impression was gained of carcinoma of the stomach.

Case 9 (*upper left*). C. C., anaplastic fibrosarcoma of left pleura, with metastasis to liver and spleen; pulmonary, hilum, inguinal, peri-aortic, and right axillary lymph nodes.
Case 10 (*upper right*). E. W., adenocarcinoma of left lobe of liver, with invasion of stomach; sclerotic metastatic involvement of first lumbar body.
Case 11 (*lower left*). B. S., pedunculated cavernous hemangioma of left lobe of liver.
Case 12 (*lower right*). P. D'L., metastasizing glomangioma of the greater omentum.

Course and Work-up.—The urine was negative. The Ewald meal showed free acid 0, combined 10, total 10. Chemical blood III, mucus plus. Blood Wassermann was negative.

First chest x-ray examination, on Feb. 22, 1938, revealed a marked widening of the aortic shadow, probably due to an aneurysm. Examination with a barium meal was also done on Feb. 22, 1938, which revealed an extrinsic pressure defect of both the greater and lesser curvatures, believed

to be due to two soft tissue shadows, probably enlarged liver and spleen. A large tumor mass was also noted in the superior mediastinum. Fluoroscopy, done on Feb. 24, 1938, revealed an enlarged liver and spleen. The mediastinal tumor mass was also seen, and an aneurysm could not be ruled out.

The patient began to run a temperature while in the ward, ranging about 101.6°, and it was noted that his scleræ became icteric. His icteric index was found to be 18.00 on Feb. 28, 1938.

Blood Examination.—Hemoglobin 75 per cent; red blood cells 3,530,000; white blood cells 2,700; color index 0.7; differential count: polymorphonuclear neutrophils 86, polymorphonuclear eosinophils 0, polymorphonuclear basophils 0, lymphocytes 10 per cent, monocytes 4 per cent; anisocytosis, poikilocytosis, moderate; hypochromia, shift to the left of neutrophils, and a few neutrophils showed toxic granules. A provocative blood Wassermann on Feb. 28 was also negative. Stools were negative for blood on a meat-free diet.

On March 1, 1938, a gland was first felt in the left side of the neck and a probable Virchow's gland was suggested. This gland was removed for a biopsy, the pathologist's report (March 2) being that of a microscopic picture compatible with a late stage (stage of fibrosis) of a Hodgkin's lymphogranulomatosis.

The temperature curve was now interpreted as that described by Pel Epstein. The patient was put on x-ray therapy, improved, and was discharged on March 24, 1938, to be followed in the x-ray therapy clinic.

He returned to the hospital on June 20, 1938, because of increasing weakness, anorexia, and weight loss. The mass in the epigastrium (liver and spleen) was still palpable. The patient went downhill rapidly and expired on June 30, 1938.

An autopsy was performed and the findings were as follows: (1) Anaplastic fibrosarcoma of the left pleura with (2) metastases to the liver, spleen, anterior mediastinal, pulmonary, hilum, inguinal, peri-aortic, and right axillary lymph nodes; (3) metaplasia of bone in the metastases; (4) confluent bronchopneumonia of both lower pulmonary lobes; (5) parenchymatous degeneration and brown atrophy of the myocardium; (6) passive congestion and cloudy swelling of the kidney, spleen, and liver; (7) fatty changes in the liver; (8) aberrant pancreatic tissue; (9) hepatosplenomegaly; (10) jaundice.

Case 10, E. W., colored female, aged 57 years.

History.—This patient was admitted to the hospital on Dec. 9, 1936, complaining of loss of weight, weakness, and vomiting of two months' duration. Vomiting occurred ten minutes after eating, accompanied by severe pain upon which soda had no effect.

Physical Examination.—Temperature 98.2; pulse 94; respirations 24; blood pressure 226/140. The heart was enlarged and of aortic configuration. About the umbilicus there was a firm node.

The impressions gained were the following: (1) carcinoma of the stomach, (2) hypertensive heart disease, or (3) possible syphilitic aortitis.

Course and Work-up.—Red blood cells 1,700,000, free acid was present; blood Kahn test showed 4+; biopsy of umbilical mass revealed adenocarcinoma.

X-ray examination of the duodenum and stomach was negative, but an extrinsic mass was seen bulging into the cardia of the stomach. X-ray examination of the spine showed osteolytic and sclerotic changes on the tenth thoracic and first lumbar vertebral bodies.

Postmortem Findings.—(1) Adenocarcinoma of the left lobe of the liver with metastasis to the right lobe, space of Douglas, greater omentum, umbilicus, tracheobronchial and peribronchial lymph nodes and pleura of both lungs; (2) invasion of wall of stomach by the hepatic tumor; (3) hemorrhagic infarct of right middle pulmonary lobe; (4) slight left ventricular hypertrophy; (5) focal syphilitic aortitis; (6) intramural fibromas of the uterus; (7)

diverticulosis of the ascending and descending colon.

Case 11, B. S., white female, aged 73 years.

History.—This patient was admitted to the hospital on July 1, 1936, complaining of pain in the lower abdomen and a lump in the lower right abdomen of five weeks' duration. She had been apparently well up until five weeks previously, when she first noticed a painful hard lump in the right lower quadrant. She was constipated for a long time, having a hard bowel movement every two or three days, but in the last two weeks she had periods of diarrhea, having two to three bowel movements daily.

Past History.—In December, 1935, she sustained a fractured left femur.

Physical Examination.—Blood pressure 122/70; temperature 98; pulse 96; respirations 22. A poorly nourished white female appearing not acutely ill.

The essential findings in the head and neck were essentially negative. There was dullness in both bases of the lungs; breath sounds diminished at both apices; râles in right base. The left heart border was near the anterior axillary line: rhythm was irregular; systolic and diastolic murmur at apex radiating at axilla. Short systolic and diastolic murmur at aorta which did not radiate to the vessels of the neck.

In the abdomen the essential findings were tenderness in the left lower quadrant, large round mass in the right lower quadrant extending up to the right costal area—the mass was hard, smooth and fixed, and exquisitely tender. Peristaltic sounds were diminished.

In the extremities the peripheral vessels were markedly sclerotic. There was an old fracture of the right upper third of the femur.

Differential diagnosis had to be made from the following: (1) generalized arteriosclerosis withc oronary sclerosis; (2) auricular fibrillation; (3) possible carcinoma of the cecum, and (4) changes incident to senility.

Course and Work-up.—The urine was essentially negative. Blood examination showed hemoglobin 65 per cent; red blood cells 5,600,000; white blood cells 5,600. Icteric index 6.25; blood Wassermann was negative. Feces showed chemical blood II; fluid in character.

X-ray examination of the colon (July 6, 1936) showed distended rectal ampulla, but no pathology was noted. Graham-Cole examination (July 8, 1936) showed non-visualization of the gall bladder. There was marked osteo-arthritis of the lumbar spine. Examination by the barium meal (July 10) revealed a constant filling defect in the greater curvature of the pars cardia of the stomach, suggestive of carcinoma.

The patient's condition remained about the same. On July 14 the temperature rose suddenly to 107° axillary, she became cyanotic, respirations stertorous, and she went into coma. A heat stroke was suspected and she expired that day.

Autopsy Findings.—Pedunculated cavernous hemangioma of the left lobe of the liver; chronic suppurative cholecystitis; cholelithiasis; hypostatic pneumonia of right lower pulmonary lobe; moderate sclerosis of the coronary arteries and marked atheroma of the abdominal aorta; parenchymatous degeneration of the myocardium, liver, and kidneys; nodose goiter; adhesions between gall bladder, liver, and anterior abdominal wall.

Case 12, P. D'L., male, Philippino, aged 40 years.

History.—This patient was first admitted to the hospital on May 5, 1937, complaining of a painless mass present in his abdomen for six months. In January he noticed that he was jaundiced and that his stools were black. He admitted being a heavy drinker and that he had had gonorrhea in 1919.

Physical Examination.—A well developed and well nourished patient. Temperature subnormal; pulse 72; respirations 20; blood pressure 150/100.

Essential Findings.—Scleræ icteric. Heart and lungs were negative. In the abdomen a large mass was felt which filled the entire right upper quadrant and ex-

tended down to the umbilicus. The mass seemed movable with respiration and the edge was smooth and sharp.

Icteric index 6.25; blood Wassermann test was negative.

An examination was made with thoro-

Case 13-*A* (*upper left*). M. C., negative stomach. (This preceded the cholecystectomy.)
Case 13-*B* (*upper right*). Cholecystectomy was done, with subsequent perigastric abscess.
Case 14 (*lower left*). Z. W., subphrenic and perigastric abscess on a tuberculous basis.
Case 15 (*lower right*). G. P., retroperitoneal tumor, probably fibrosarcoma.

Course and Work-up.—Hemoglobin 49 per cent; red blood cells 2,750,000; white blood cells 9,900; polymorphonuclears 88 per cent. Stools were positive for blood and grossly tarry. The urine was negative.

trast and the liver and spleen were well visualized and appeared within normal limits.

Further Course.—The patient was transferred in July to a surgical ward for an

exploration. The stomach appeared enlarged and an inoperable carcinoma of the stomach was considered. A biopsy was taken and was reported as a Schwannoblastoma.

The patient left the hospital only to return in September. This time he complained of weakness, shortness of breath, loss of weight, and enlargement of his abdomen. He appeared anemic and quite weak. Râles were heard in both pulmonary bases, and the liver was four fingers down; there was fluid present in the abdomen. The mass in the abdomen was slightly tender and large lymph nodes were palpable in the inguinal region.

X-ray Examination.—All the bones and chest were negative for metastasis. An abdominal paracentesis yielded 3,900 c.c. of amber-colored fluid, and microscopic examination showed large islands of degenerated cells. In the ward he had much abdominal pain from which he had relief after his abdomen had been tapped. He grew weaker and expired five weeks after his second admission, approximately one year after the onset of his illness.

Autopsy Findings.—(1) Metastasizing glomangioma of the greater omentum; (2) metastases to the mesentery, the parietal peritoneum, the wall of the stomach, the liver, and the right inguinal nodes; (3) brown atrophy of the myocardium and liver; (4) thorotrast pigmentation of the reticulo-endothelium; (5) ascites; (6) passive congestion of the lungs, spleen, and kidneys; (7) fibrous obliteration of the pleural cavities.

Case 13, M. C., colored female, aged 45 years.

Operated on for cholecystitis. Cholecystectomy done June 7, 1937. Ran postoperative low grade fever from 100 to 101° for three weeks, then began to have persistent vomiting, nausea, and anorexia. A mass was felt in the epigastrium four hours after operation. This mass felt reducible.

Operated on again six weeks after the first operation and perigastric abscess found. Methylene blue given by mouth was found on her surgical dressings. Expired seven days after second operation.

Case 14, Z. W., male, aged 46 years.

History.—This patient was admitted to the hospital June 22, 1937, complaining of a large mass in the abdomen of three months' duration. He was being treated for peptic ulcer. About three months previously, he noticed a small hard lump in the right upper quadrant. This lump grew progressively in size, gradually extending across and around the abdomen. The mass had become somewhat softer in consistence prior to admission.

Physical Examination.—Temperature 99.6; pulse 86; respirations 22; blood pressure 136/92. The essential findings in the head and neck were negative; the chest was symmetrical; the lungs clear; the heart had a systolic murmur over the apex. There was a large soft mass in the epigastrium and right upper quadrant, the size of a grapefruit; the liver was enlarged; the extremities were negative.

In making a diagnosis of echinococcus cyst of the liver, it was necessary to rule out amebic cyst and pancreatic cyst.

Course and Work-up.—The patient was proctoscoped on June 27, the findings being essentially negative. A barium meal on the same day revealed evidences of extrinsic pressure on the greater and lesser curvatures of the stomach, probably due to a large liver and spleen. Some evidence of a hiatus hernia was also noted.

In the ward, the mass became smaller and fluctuant. It was aspirated and no fluid was obtained. Since the patient ran a septic temperature and the mass persisted, an exploratory laparotomy was deemed advisable.

Stomach Contents.—The Ewald meal showed free acid 36 degrees, combined 14 degrees, total 50 degrees. The stools were essentially negative.

Blood examination showed red blood cells 2,760,000; white blood cells 12,200. Urine was essentially negative. Blood chemistry showed urea nitrogen 13.00. Blood Wassermann was negative. A barium enema

on July 12, 1937, showed that the colon filled well, showing no pathology.

The patient had an exploratory operation on July 24, at which a swelling was found in the epigastrium about the size of a grapefruit, in which there was a fluctuant area surrounded by a hard crater. A foul bloody purulent discharge was obtained. The abscess was drained. The patient continued to run a post-operative temperature, and the wound drained rather profusely. He gradually began to "lose ground" and go downhill. A biopsy from the abdominal wall on Sept. 4 revealed caseous tuberculosis. He expired on Sept. 16 with a terminal bronchopneumonia. The final conclusion since the chronic nature of the abscess was determined was a subphrenic abscess on a tuberculous basis.

Case 15, G. P., colored female, aged 48 years.

History.—This patient was admitted to the hospital on Feb. 9, 1938, complaining of one fainting spell, abdominal pain, upper abdominal distress, and constipation, all of three months' duration.

The patient had also been troubled with fullness after meals, pyrosis, and nausea for the same length of time. In that period she had lost her appetite and thirty to forty pounds in weight. She had had one fainting spell which she had been told was due to her high blood pressure. She had been told she had "bad blood" and had received twelve injections in the arm and twelve injections in the hip, at the end of which treatment she had been told her blood was negative. She was advised to continue treatment, but did not do so. During the past two months she grew weaker, and was confined to bed. In addition, she had difficulty in defecation and urination, and noticed shortness of breath with palpitation of her heart.

Past History.—Neuritis eight years previously; rheumatism, scarlet fever, and malaria as a child.

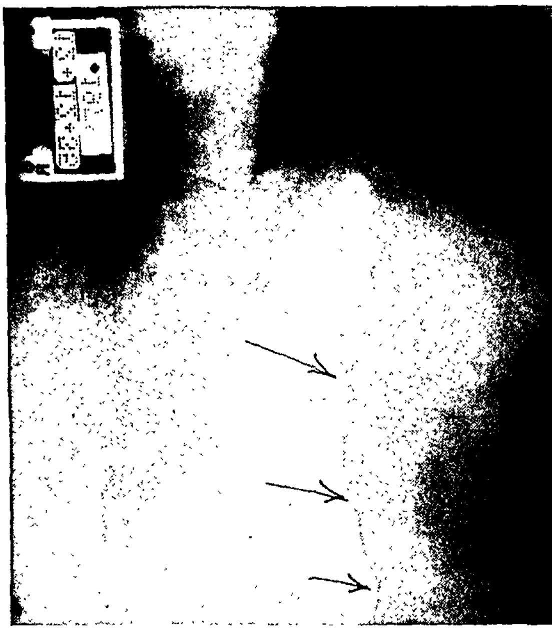
Physical examination revealed an extremely weakened colored female, lying quietly in bed, and appearing acutely ill. Temperature 99.4; pulse 80; respirations 48; blood pressure 190/106. The essential findings in the eyes were as follows: right pupil eccentric, small capsular fragments in right anterior chamber (previous operation); marked bilateral exophthalmos. The neck was essentially negative. The chest was markedly asthenic; breasts were atrophied; supra- and infraclavicular retraction. The lungs were clear. The heart, A-2, accentuated; systolic murmur heard best at the right second interspace. Examination of the abdomen showed dilatation of the veins of the scaphoid. There was a mass the size of an orange protruding from the left costal margin, which was firm, fixed, and somewhat tender. In the groin there was a bilateral, discrete, firm, non-tender inguinal adenopathy. The reflexes, genitalia, rectum, extremities, and pelvis were essentially negative.

Impression.—Differential diagnosis had to be made among: (1) scirrhous carcinoma of splenic flexure; (2) secondary anemia, and (3) sarcoma originating from the left costochondral area.

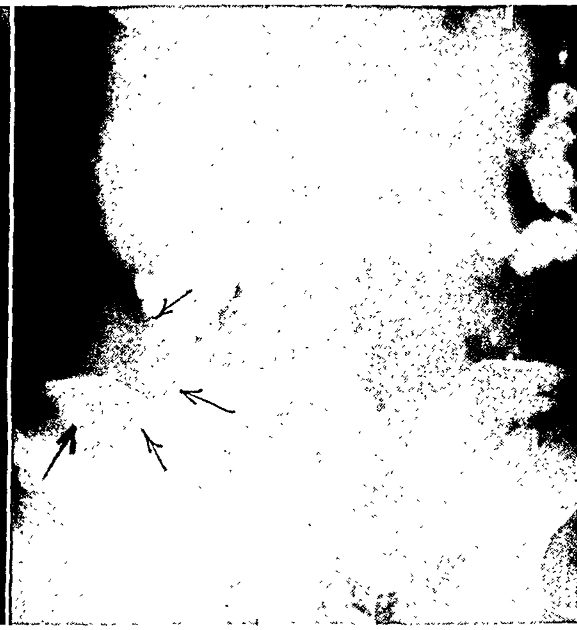
Course and Work-up.—X-ray examination of the chest and abdomen on Feb. 11, 1938, revealed moderate increase in the hilar markings. The flat plate of the abdomen revealed a round area of varying degrees of calcification in the left pelvis which was believed to represent a calcified ovary. There was another small round area of density to the left of the left transverse process of the fifth lumbar vertebra. A barium meal (Feb. 23) revealed a large round palpable mass in the left upper quadrant causing extreme pressure on the stomach. Intravenous pyelogram (March 2) revealed considerable clubbing of the calices of the right renal pelvis.

Stomach Contents.—The Ewald meal showed free acid 0, total acid 10, combined 10. The feces showed chemical blood on two occasions.

Blood Examination.—Hemoglobin 55 per cent; red blood cells 5,200,000; white blood cells 5,100. The urine revealed many white blood cells and occasional hyaline casts. The blood Wassermann was negative. Aspiration biopsy of left costal



Case 16. O. T., chronic myelogenous leukemia; large spleen.



Case 17. C S., ovarian cyst external to ascending colon.

margin revealed no tumor cells. The mass remained about the same size and an exploratory laparotomy was advised. Operation was performed March 8, 1938, and a large retroperitoneal and retrogastric hard mass found, well demarcated laterally, adherent posteriorly to the spine and to the abdominal wall in the region of the left kidney and adrenal—above the pancreas and below the spleen. No attachment to the stomach or colon was found. No peritoneal or liver metastasis was noticed. A fibrosarcoma was considered the most probable diagnosis. The patient made an uneventful post-operative recovery, was discharged on March 19, 1938, and referred for x-ray therapy.

Case 16, O. T., colored male, aged 51 years, occupation, worker in a steel foundry.

History.—This patient was admitted to the hospital Aug. 31, 1934, complaining of pain in the abdomen and a cough of seven months' duration; shortness of breath and swelling of ankles of three weeks' duration. He had seemed perfectly well up until Christmas, 1933, when he caught a cold and developed a dry hacking cough which persisted until the time of admission. At about the same time he developed a pain in the left upper quadrant, of a numb aching character. He had constipation of long standing. About three weeks before admission, for the first time, he became dyspneic and his ankles became swollen. These symptoms became progressively worse and he also developed attacks of nocturnal dyspnea. He had lost about thirty pounds in weight in the past six months.

Past History.—He had had a scrotal abscess incised. Gonorrhea and chancre, thirty years previously.

Physical Examination.—A fairly well nourished colored male, who appeared decompensated. Temperature 98.4; pulse 72; respirations 20; blood pressure 132/72.

Essential findings were: cervical and axillary (small) lymphadenopathy, with widened mediastinal dullness. The apex of the heart was enlarged to the left; systolic murmur and thrill at apex. The

liver was two fingers below the costal margin. The spleen was firm and a handbreadth below the left costal margin. The abdomen, slightly distended, contained no fluid. There was edema of the lower extremities.

Impressions.—(1) Leukemia—probably myelogenous; (2) rheumatic heart disease with beginning decompensation.

Course and Work-up.—Urine, bile II, otherwise essentially negative. Blood examination showed hemoglobin 46 per cent; red blood cells 2,860,000; white blood cells 197,400; color index 0.9; platelets 310,000. Differential count as follows: polymorphonuclear neutrophils 33 per cent; polymorphonuclear eosinophils 5 per cent; polymorphonuclear basophils 13 per cent; lymphocytes 3 per cent; abnormal forms—myeloblasts 9 per cent, myelocytes 13 per cent, metamyelocytes 17 per cent, red cells 7.5 per cent, normoblasts 2 per cent.

Blood Chemistry.—Urea nitrogen 14.50; uric acid 4.75; sugar 130.0; cholesterol 167.0. Blood Wassermann was negative; EKG showed evidence of minimal myocardial injury. Examination by barium enema showed that the colon filled well, showing no apparent pathology.

A diagnosis of chronic myelogenous leukemia with rheumatic heart disease was made and the patient was discharged Sept. 12, 1934, to be on x-ray therapy and iron and liver capsules. He was re-admitted to the hospital on Dec. 10, 1935, because he continued to lose weight and complained of pain in his abdomen.

Further Work-up at this Time.—Barium meal (Feb. 12, 1935) showed the mass on the left side believed to be spleen; the stomach was negative. A chest plate showed that the transverse diameter of the heart measured 60 mm. to the right of the midline and 90 mm. to the left. The contour was of the aortic type.

The white blood count returned to normal and he was discharged on Dec. 23, 1935, with x-ray therapy advised.

Case 17, C. S., white female, aged 32 years.

History.—Pain in the right lower quadrant, worse during menstrual period; had no relation to food; was intermittent, dull in character. Onset was gradual about four years previously. The past history was essentially negative.

Physical examination revealed a palpable mass in the right lower quadrant.

A gastro-intestinal x-ray series revealed a circular mass external to the ascending colon. Laparotomy revealed a pedunculated ovarian cyst.

Case 18, M. C., white female, aged 41 years.

History.—The patient had pain in the right upper quadrant, not related to food intake; occasional vomiting. She had experienced vague gastric disturbances for many years; occasional vomiting shortly after eating for several years past; no other relevant data.

Roentgenological Work-up.—Gastro-intestinal examination revealed a well-defined, smooth-bordered filling defect near the pylorus along the greater curvature, probably due to extra-gastric pathology.

Operation revealed a cyst of the omphalo-mesenteric duct.

Case 19, J. B., white male, aged 72 years.

History.—Loss of weight; no special gastro-intestinal symptoms; feeling of fullness in lower abdomen; frequent and unsatisfactory urination. The past history is essentially negative.

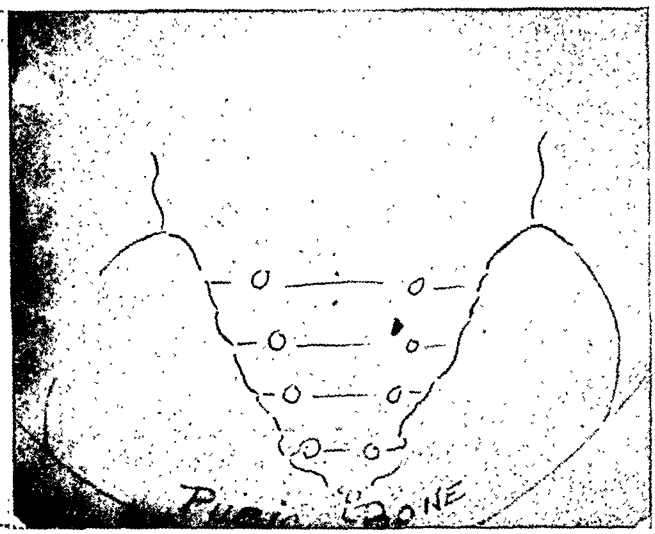
Physical Examination.—Pendulous abdomen; large palpable mass in suprapubic region, not tender to pressure.

Roentgenological Work-up. Six hours after the administration of a barium meal the jejunum and ileum were disclosed to be high in position and resting on some tumor mass, presumably fluid in content. Distended urinary bladder was suggested.

Subsequent Work-up.—Urine analysis showed no decomposition. Catheterization removed 39 ounces of residual urine, with disappearance of tumor mass. A large palpable prostate was present. Prostatectomy was done, with relief of symptoms.

Case 19-A, W. H., white female, aged 48 years.

Case 18. M. C., cyst of omphalo-mesenteric duct.



Cases 19 and 19-A. J. B. and W. H. (2 cases), high position of small bowel due to marked retention of residual urine in bladder.

History.—Difficult and unsatisfactory urination, intermittent in character, of about seven or eight years' duration, becoming more annoying for the last several years.

Physical Examination.—Well nourished individual; palpable mass in suprapubic region, fluctuant.

The roentgenologic findings were similar to those in the previous case.

Cystoscopic Examination.—This revealed an anomalous redundant fold of mucous membrane in the bladder, just above the ureteral orifice, which acted as a flutter valve. Catheterization removed a large quantity of urine, with total disappearance of the tumor. Separation of this membrane gave complete relief.

Note that both Cases 19 and 19-A were negative for syphilis. A neuropathic bladder had to be ruled out.

Case 20, B. S., white male, aged 60 years; occupation, custodian.

History.—This patient entered the hospital Nov. 28, 1937, complaining of urinary incontinence. He had been bothered with prostate trouble for the past 20 years. He had no sense of micturition and desired to urinate after voiding. He also had occasional hematuria. For the past two years he has had dyspnea, and some intermittent claudication.

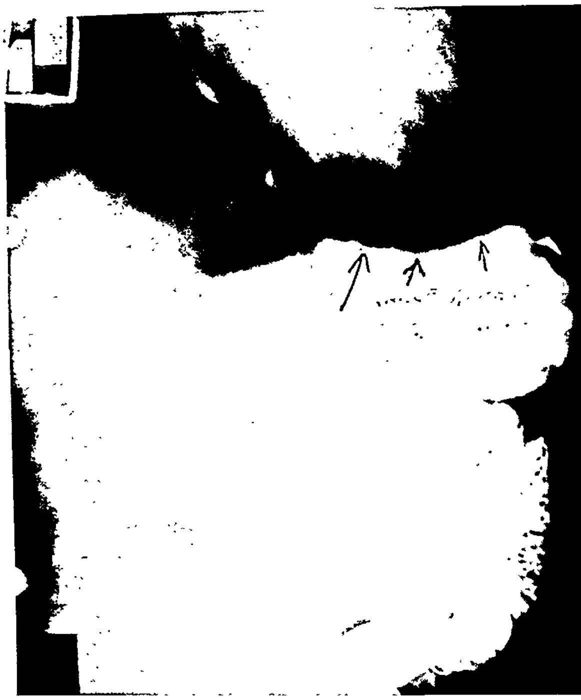
Past History.—Had gonorrhea at the age of 30 years, and was being treated for syphilis at the time of admission. Three years previously he had had sudden paralysis of the left arm.

Physical Examination.—Temperature 98 degrees; respirations 18; pulse 72; blood pressure 190/110. Essential findings were Argyll Robertson pupils; neck negative; basal râles in the chest; heart enlarged, tones soft, and a systolic murmur at the apex; tambour A-2; abdomen scaphoid; liver one finger down; bladder distended; genitalia negative; rectal hemorrhoids and slightly enlarged prostate; rectum gapping; reflexes, exaggerated Achilles and plantars; extremities essentially negative.

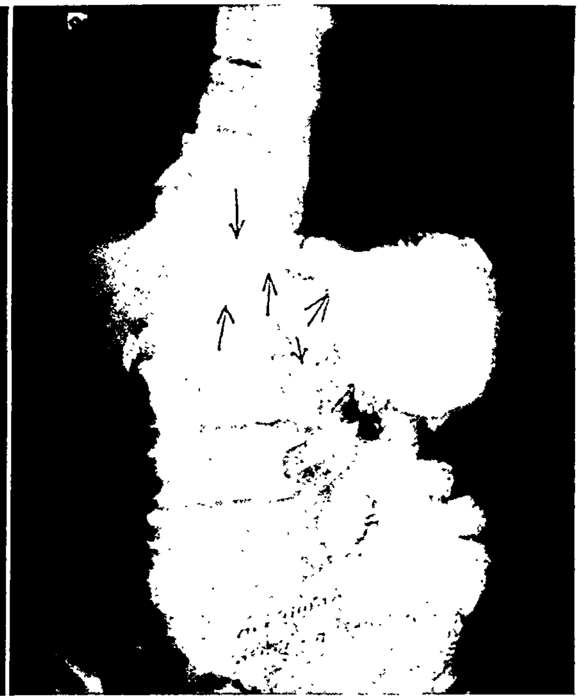
Impressions.—(1) Central nervous system, syphilis; (2) benign prostatic hypertrophy; (3) organic heart disease. *Etiologic:* (1) arteriosclerosis; (2) hypertension; (3) syphilis. *Anatomic—cardiac enlarge-*

ment: (1) coronary sclerosis; (2) syphilitic aortitis. *Physiological*—decompensation. *Functional*—Class II B.

There was an obliteration of the costophrenic angles. Cystoscopy: On Dec. 16, 1937, findings compatible with a diagnosis



Case 20. B. S., marked cardiac enlargement, with pressure defect on cardia of stomach.



Case 21. J. W., abdominal aortic aneurysm.

Course and Work-up.—Spinal tap: Clear; pressure, normal; Pandy, negative; cells, negative; spinal Wassermann, negative. *Blood Examination.*—Hemoglobin 56 per cent; red blood cells 3,740,000; white blood cells 9,950; color index 0.80; differential count: polymorphonuclear neutrophils 79 per cent; polymorphonuclear eosinophils 0; polymorphonuclear vasophils 1 per cent; lymphocytes 18 per cent; monocytes 2 per cent; anisocytosis, poikilocytosis and hypochromia. Stomach contents: Alcohol meal = free acid — 0; combined 4°. Feces: Showed trace of chemical blood. Urine: Albumin; occasional white blood cell. Blood chemistry: Urea nitrogen 61.00; creatinine 4.44. Blood Wassermann: Plus 3. Chest plate (Nov. 3, 1937): Revealed cardiac enlargement, and an undue prominence of the aortic arch. Increase of the hilar markings with calcification of the lymph nodes.

of trilobar prostatic hypertrophy and neurogenic bladder. Resection was advised, and the patient was transferred to the genito-urinary service.

Case 21, J. W., colored male, aged 65 years; occupation, carpenter.

History.—This patient was admitted to the hospital on Feb. 19, 1938, complaining of: (1) sickening pain in the abdomen; (2) sharp pains over heart, radiating to the left shoulder; (3) severe frontal headache (for two or three years); (4) dyspnea; (5) sharp pains over the heart radiating to the right shoulder (for two or three days). In 1924 this patient received a knife-stab wound in the abdomen to the right of the umbilicus. He was explored and had a long convalescence. He was told his liver was injured. In 1935, he began to get a "sickening, gnawing pain" in the abdomen which was accompanied by profuse vomiting and headache. In September, 1937, he

was in the Cook County Hospital for about a month, being discharged somewhat improved and referred to the clinic which he had been attending ever since.

Past History.—Measles and "yellow jaundice," malaria, pneumonia (twice), pleurisy, and gonorrhea (twice).

Physical Examination.—Revealed a colored male, in a fair state of nutrition, not acutely ill. Blood pressure 160/110 (in left and right arms); pulse 76; respirations, 20; temperature 98 degrees. Essential findings in the head were negative; *in the neck, there were small glands in the* right anterior. The chest was symmetrical. There were râles at the bases of both lungs. The heart was essentially negative. In the abdomen there was a right paramedian scar, with slight distention. A mass was palpable in the abdomen, extending from the epigastrium on the right side down to the pelvis—expansile and pulsating. The rectal sphincter was relaxed; the mucosa, redundant. The prostate, slightly enlarged. The genitalia, extremities, and reflexes were essentially negative.

Impressions.—(1) Abdominal aortic aneurysm on traumatic basis (consider a dissecting aneurysm); (2) coronary sclerosis; (3) cardiac asthma; (4) hypertension.

Course and Work-up.—Feces, one specimen plus chemical blood; urine, albumin III, bile I; blood Wassermann, negative; EKG, minimal amount of myocardial damage. X-ray examination of the abdomen and spine, Feb. 16, 1938, showed *marked osteo-arthritis of the lumbar spine;* no definite evidences of erosion. Examination by barium enema on Feb. 23, 1938, showed that the colon filled well, showing no pathology. Two days later, again by barium meal, a pulsating mass, extrinsic to the stomach and compressing it and the duodenum from below, was noted. The patient complained of marked night sweats while in the ward. He left the hospital of his own accord on Feb. 23, 1938.

THE LIMITATIONS OF INTRACAVITARY RADIUM THERAPY IN CANCERS OF THE CERVIX OF THE UTERUS[1]

By A. LACASSAGNE, M.D., *Paris, France*

From the Institute of Radium

DURING the first half of a period of almost 40 years, which separates us from the beginning of the radium therapy of cancer, the technic has varied but little. In the last twenty years, however, due, above all, to the possession of relatively large quantities of radio-active substances, rapid changes have taken place in the methods of their application. On the other hand, the development of x-ray apparatus of high voltages and the utilization of neutrons in therapeutics—still in the experimental stage—are methods of treatment of the future, the value of which has not yet been definitely determined.

The best guide for orientation should be the exact knowledge of the therapeutic results already attained. In an article entitled "The Place of Radium in Treatment of Cancer,"[2] the conclusion was reached that practically "the small curietherapy foci in the form of tubes, moulages, needles, etc., applied for superficial intracavitary or interstitial applications, seem destined to endure as long as the radiotherapy of cancer itself. They will persist, moreover, as an indispensable arsenal because of a varied action, at the same time very powerful and very localized, which only they can exercise."

On checking this statement, we will see the value of the local radium treatment of a quite common type of cancer, such as that of the cervix, for which the technic of application has for a long time been well established.

Table I shows strikingly the evolution that the method of irradiation of this type of cancer has undergone under the influence of the increase of radiotherapeutic material, at the Institute of Radium, in Paris.

It is apparent that for several years the intracavitary curietherapy was the only method employed, irrespective of the extent of the lesion, and was followed by a hysterectomy unless such an operation was contra-indicated. After several years, the radium-surgical combination was abandoned. It is no longer practised, save in a few cases of a special histological type, or because of conditions which render complete and thorough irradiation impossible. But, since 1923, in a greatly increasing number of cases, local radium therapy has been combined with x-ray therapy, and in 1924, with telecurietherapy, practised first with one, then with three, and then with four grams of radium (since 1934, with eight grams). The technic of combination of intracavitary radium therapy and transpelvic therapy, thus assumed first place. This change is apparent from the fact that of 404 patients, treated between the years of 1919 and 1923, 345, or 85 per cent, were treated only by local radium application; from 1924 to 1932, of 956 patients only 181, that is to say, 18 per cent, have undergone intracavitary curietherapy as the only treatment.

The years 1923 and 1924 thus mark an important change in the therapeutic methods of the Institute of Radium, in Paris. Until then, efforts had been, above all, directed toward the perfection of the intracavitary curietherapy. The technic of this method was perfected in 1922, and it may be said that no important changes have been made in it since then. However, if the results in these cases appeared to be satisfactory in the beginning, the benefits derived from the treatment of cases in Groups III and IV were mostly

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[1] This is one of a series of papers contributed by friends and former pupils of I. Seth Hirsch, M.D.

[2] Lacassagne, A.: Canadian Med. Assn. Jour., 38, 9, 1938.

transitory or even absent. The combination of local and external irradiation improved these results.

But this is not the subject of our discussion at this moment. We desire to study the rôle which the employment of a small tube of radium, introduced into the uterine or vaginal cavity, plays in the cure of cancer of the cervix. We shall consider, first, only those cases in which the cancer was apparently limited to the cervix, that is to say, those in Group I, treated by local curietherapy only, at the time when this technic of irradiation was definitely established (since the beginning of 1923). We shall analyze the results obtained after a review of at least five years which includes 79 patients treated up to the year 1932. But it is important to begin by recalling briefly the main points of the technic employed by the intracavitary curietherapy.

The tubes used measure 22 × 3.15 mm. or 4.15, depending on the thickness of the platinum filter, which was either 1 or 1.5 mm. These contain from 6 mgr.66 to 13 mgr.33 of radium. Usually the applicator which is introduced into the uterine cavity and occupies its entire length, consists of three tubes with a 1 mm. platinum filter, placed in tandem fashion in a rubber tube, thus representing a quantity of radium equal to 66 mgr.66. The application is made over a period of five days and corresponds to a dose of 8,000 mg. an hour. During the same time, or after the uterine application, the vaginal vaults are irradiated with three tubes with a 1.5 mm. filter enclosed in cork tubes 20 mm. in diameter. Two of them are held in place in the lateral *cul de sacs* by a special device and the third is applied to the cervical orifice. The quantity of radium which these contain is also 66 mgr.66. Thus the vaginal dose obtained by this arrangement in five days also amounts to 8,000 mg.-hours. Table II shows the results obtained in the 79 cases so treated.

The efficacy of this method of treatment is shown by the fact that 59 of the 79 cases treated may be considered as having been cured (74 per cent). In fact, 58 are actually living for from five to fourteen years, and one patient has died of cardiopathy at the age of 78, without any evidence of recurrence for six years.

There remains to be considered, 18 cases in which radium therapy failed, two cases having died without apparent recurrence, one of pulmonary tuberculosis two years after the treatment, and one of bronchopneumonia three years afterward. One patient was not seen after the treatment; she died of cancer one year later.

But it is interesting to analyze the 16 recurrences: (*A*) Four were localized to the cervix itself; (*B*) nine to the parametrium through lymphatic invasion, the uterus itself seeming to be free of involvement, and (*C*) three by distant metastases, though the pelvic examination did not disclose the cancerous localization.

TABLE I.—INTRACAVITARY CURIETHERAPY

Years	No. Patients Treated	Alone	Combined with Surgery	Combined with X-ray Therapy	Combined with Telecurietherapy	X-ray Therapy Alone	Telecurietherapy Alone
1919	103	93	10				
1920	98	97	1				
1921	48	42	5	1			
1922	69	62	2	1		4	
1923	86	51	6	17		12	
1924	80	22	5	34	7	12	
1925	97	13	5	27	35	6	11
1926	98	22	4	13	43	7	9
1927	110	22	1	18	44	21	4
1928	104	10	2	42	41	8	1
1929	117	15	2	42	49	5	4
1930	121	21	1	27	59	12	1
1931	113	22	1	24	57	6	3
1932	116	34	4	17	53	6	2

(*A*) *Local Recurrences.*—Three patients, in whom the recurrence appeared after four, five, and ten months, were hysterectomized; the operation did not prevent a new recurrence, which led to death after six months, eight months, and two and one-half years, respectively. The fourth patient had refused surgical intervention, when, 15 months after radium therapy, the recurrence became manifest. The disease spread slowly for two and one-half years.

(*B*) *Parametral Recurrences.*—These nine cases represent the most frequent type of recurrence. In six cases there were signs of compression, pain, or swelling of a limb, due to metastasis to external iliac or presacral glands. In three cases, the recurrence was disclosed by the loss of weight and the development of a tumor, placed high in the pelvic cavity and giving no signs of compression.

The dates of the appearance of the first sign varied from three months to three years, in seven cases. In two cases, a state of apparent good health had been maintained, in one for seven and one-half years and in the other for one and one-half years.

The x-ray therapy and telecurietherapy applied to several of these tumors were inefficacious. Death followed between five months and two and one-half years after the first signs of recurrence.

(*C*) *Extrapelvic Recurrences.*—In one case of a somewhat special histological form, the signs and the development of the disease led to an error in diagnosis. It was a cancer of the body of the uterus spreading to the cervix which, after a year of disappearance, produced a general metastasis, leading to death after six months, from foci in the liver, stomach, and brain.

The two other cases are more classic: in one, after three years of apparent cure, there developed an abdominal prevertebral tumor and in the other a vertebral metastasis appeared after four years.

TABLE II.—RESULTS OF CURIETHERAPY IN TREATMENT OF EPITHELIOMA OF CERVIX OF UTERUS
(Report on 79 Cases Treated from 1923 to 1932)

Years	No. Cases	Living without Recurrence	Dead, from Intercurrent Disease More Than Five Years after Treatment	Dead, from Intercurrent Disease Less Than Five Years after Treatment	Dead, from Complications Caused by Treatment	Dead, from Cancer; Cases not Seen after Treatment	Local Recurrences	Parametral Recurrence	Extrapelvic Recurrence
1923	8	6					1	1	
1924	4	3						1	
1925	7	5						2	
1926	4	4							
1927	9	7					2		
1928	4	2						1	1
1929	9	5	1	2				1	
1930	11	9						2	
1931	9	6				1		1	1
1932	14	11			1		1		1
Total	79	58	1	2	1	1	4	9	3

DISCUSSION

The necessity of treating the cases of inoperable cervico-uterine cancer, or those in the limit of operability group, by a total

irradiation of the pelvis, is now admitted by most radiologists. This method of treatment is best attained, at least at present, by local curietherapy combined with transpelvic radiotherapy. The increase in the number of cures obtained by this technic is shown by numerous statistics. We will not republish those of the Institute of Radium which appeared in the first paper published by the Organization of Hygiene of the League of Nations, dedicated to an inquiry on the results of radium therapy of cancer of the cervix of the uterus. We will limit ourselves to the statement that during the course of 10 years, from 1923 to 1932, the cures obtained by means of intracavitary curietherapy alone have been 38 per cent in Group II cases, 6 per cent in Group III cases, and none in Group IV cases. In contrast with these mediocre results of the local application, is the percentage of cures shown in the last statistics, established five years after the treatment. Based on the combined irradiation, the statistics show Group II, 53 per cent; Group III, 41 per cent, and Group IV, one cure out of the six cases treated. The great benefit of the combination technic is thus proved, as far as cancer of the cervix is concerned. Is it also true for cases of Group I? Here we lack the facts. It is only in the last few years that combined radiation has been applied to cancer limited to the cervix. It is still impossible to judge if after five years the proportion of cures will exceed remarkably the 75 per cent obtained by curietherapy. In reference to this method, it is, however, important to appreciate the considerable increase in fatigue, and the time lost in giving the patient this combined treatment, and the great quantity of material this method demands. Instead of from five to ten days of hospitalization for an application of radium, there is necessary one and one-half months of daily irradiation with x-rays, in order to obtain the absorption of a similar quantity of penetrating rays to that emitted by the radium. Nor can this always be accomplished without certain local and general reactions which may be very painful, sometimes even dangerous, or without the risk of certain permanent sequelæ.

It may be possible to draw some conclusions from the analysis of the recurrences in cases in Group I after intracavitary radium therapy; against 59 patients cured, there are here 17, 22 per cent. We have to discard three cases of extrapelvic recurrence. In these patients, there had existed for a long time, previous to the treatment, foci of disease, so that neither a combined radium therapy nor a hysterectomy could have changed the fatal termination.

There remain 14 intrapelvic recurrences. In only four of these was the extension uterine, probably because of non-sterilization of the primary lesion. Are these failures due to the type of cancer which belongs to the relatively insensitive tumors? Apparently they are not, for the microscopic examination showed the ordinary varieties of epitheliomas of the cervix.

In explaining the local recurrences, one is tempted to consider them as examples, confirming the fact which has been proven by experiment, that, for a certain kind of cell, no lethal dose exists; that lesions in similar tissues, exposed to the same conditions of homogeneous irradiation, do not always show similar results. Only this is definite, that there exists no certainty either as to the probability of survival of tissues or a certitude of their destruction by any determined irradiation. With the dose applied in intracavitary curietherapy to an epithelioma limited to the cervix, the probability that some cancerous cells escape death seems to be about 5 per cent. It is evident that this probability would diminish if the size of the dose were increased.

Concerning the parametral recurrences, most of them are the consequences of the unequal distribution of the irradiation by the intracavitary curietherapy technic; the intensity which is generally sufficient to kill the cells of cervical cancer, irradiated at a short distance and by cross-fire, is absolutely incapable of sterilizing the distant glandular invasion.

Under these conditions, combined radium therapy (local or transpelvic), should be used, even in cases in Group I, until the statistics have proven that the increase of cures does not compensate for the inconvenience of this method, which is not very probable.

CONCLUSIONS

1. The efficacy of local radium therapy alone is proved by the fact that the cure can be obtained by this method in 74 per cent of the cases of cervico-uterine cancer in the first degree.
2. On the other hand, this technic is frequently not sufficient in Group II cases, and almost completely ineffectual in cases in Group III.
3. The study of the recurrences justifies the hope that a greater proportion of cures in Group I will be obtained by treating these cases systematically with a combination of intracavitary and transpelvic irradiation.

FURTHER STUDIES ON THE PROBLEM OF MITOGENETIC RADIATION[1]

By HANS BARTH, PH.D., *and* OTTO GLASSER, PH.D., *Cleveland, Ohio*

From the Department of Biophysics, Cleveland Clinic Foundation

ALTHOUGH more than 600 papers on the problem of mitogenetic radiation have been published, no uniform conclusions have been reached, even in regard to the fundamental question of the existence of this type of radiation. We (1) believed that, since there were so many contradictory reports, it would be desirable to investigate the problem by direct collaboration. This is a preliminary report of our researches.

Detector Arrangement.—The Geiger-Müller counter tubes, which we have used in our Cleveland laboratory for several years, are similar to those used in Gurwitsch's laboratory in Leningrad. However, while the presence of mitogenetic radiation was demonstrated in Gurwitsch's laboratory (2) with this type of apparatus, we were unsuccessful in obtaining positive results beyond the experimental error, though many different possible sources of radiation were used (3). Consequently, our first task in this collaboration was to construct counter tubes of the type used in Leningrad out of materials available in this country, and then to test them with a source of radiation which also had been used in Leningrad and which is easily reproducible.

The construction of the counter tube which we used has been described previously and (2) is shown diagrammatically in Figure 1. The cathode tube, *C*, has an inside diameter of 0.5 cm. and is 4 cm. long. In some of the tubes we used clean copper as the photo-electric surface, in others copper iodine; the preparation of these latter surfaces was described recently (2). The counter tube, *C*, is enclosed in a quartz test tube, *Q*, which is sealed with apiezon wax to the glass vessel, *G*. The counter is filled with hydrogen under a pressure of 15 mm.; in some experiments the pressure was increased to 150 mm.

In our first experiments, we connected the Geiger counter tubes to a circuit with a high tension rectifier system which fur-

[1] This is one of a series of papers contributed by friends and former pupils of I. Seth Hirsch, M.D.

TABLE I.—ACTIVITY OF PAPERS

No. Experiments	Dark Rate		With Paper Tube		Dark Rate	With Paper Tube	Difference	
	Counts	Minutes	Counts	Minutes	Counts/1 min.	Counts/1 min.	Absolute	Percentage
A. Experiments with papersheets, which had been stored in the laboratory for a long time								
2	120	3.2	120	1.9	37.5 ± 3.4	63.2 ± 5.8	25.7 ± 6.7	68
3/4	300	15.8	300	8.9	19.0 ± 1.1	33.5 ± 1.95	14.5 ± 2.0	76
23	300	24.4	300	16.7	12.3 ± 0.72	18.0 ± 1.00	5.7 ± 1.23	46
B. Comparison of old sheets and new paper								
9/10								
old	630	29.0	630	22.5	21.7 ± 0.87	28.0 ± 1.1	6.3 ± 1.41	29
new	630	29.0	630	27.7	21.7 ± 0.87	22.7 ± 0.91	1.0 ± 1.26	5
29/36								
old	200	26.1	200	15.5	7.7 ± 0.54	12.9 ± 0.91	5.2 ± 1.06	68
new	500	45.7	500	44.2	10.9 ± 0.49	11.3 ± 0.51	0.4 ± 0.71	4
C. "New" papersheets several days later								
30/f	400	41.0	400	32.4	9.8 ± 0.49	12.4 ± 0.62	2.6 ± 0.79	26
31/f	600	64.5	600	58.0	9.3 ± 0.38	10.3 ± 0.42	1.0 ± 0.57	11

nished a potential of about 1,000 volts and a counting arrangement with a two-stage amplifier and a Cenco counter; we had used this circuit for several years in our laboratory. However, *in order to avoid all possible disturbances from fluctuations in the line, we changed the circuit and operated the counter with dry cell batteries and observed the discharge with a string electrometer.* This circuit is also shown in Figure 1.

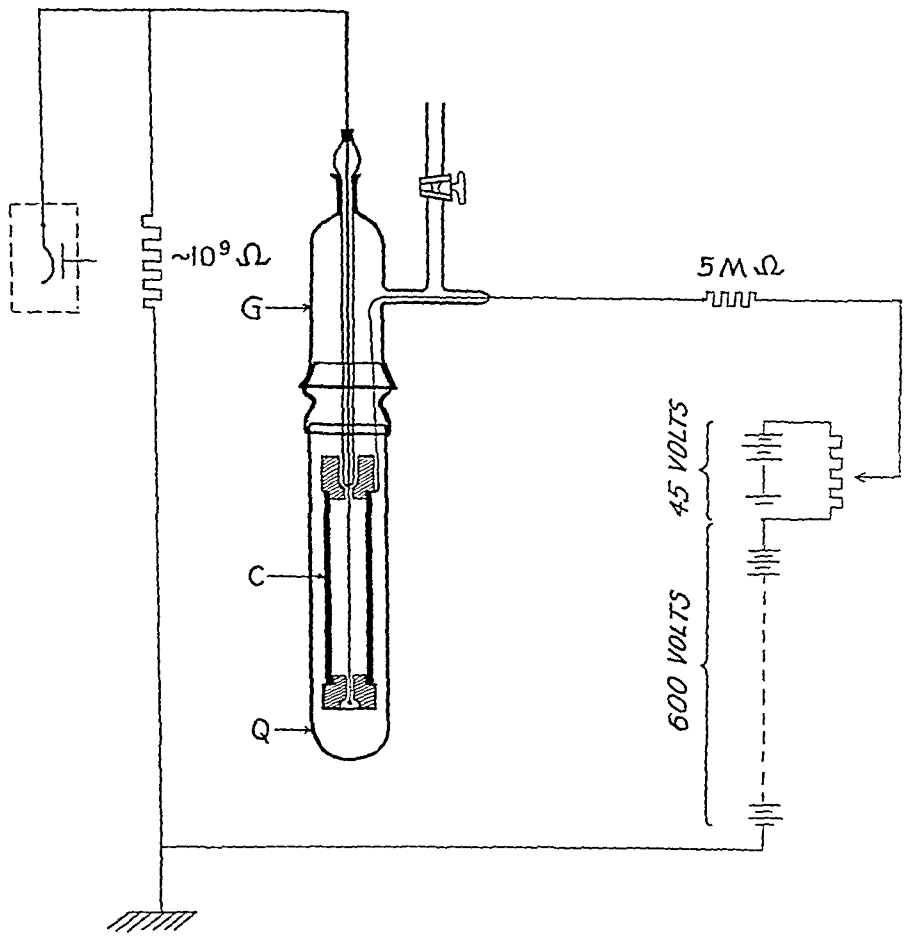

Fig. 1.

This change was necessary because the electrical impulses of the Leningrad counter tubes were very much weaker when used with the amplifier circuit than in our counter tubes; consequently the recording device did not respond to the Leningrad tubes until the voltage was increased considerably beyond the proper working voltage required for the tube. If the amplification factor of the recording device was increased, outside electrical disturbances appeared which prevented satisfactory readings. *Therefore, the amplifier was first replaced by a string electrometer and later by a "magic eye."* The counters worked satisfactorily with this circuit only at pressures of 150 mm., which was about ten times that used in the earlier work in Leningrad.

A number of experiments were made with this set-up, one of which showed a definite indication of a positive effect (Table IV, Counter 1). However, with the specific radiation source used in our experiments, a definite increase in the counting rate usually could not be obtained with the cell working at pressures as high as 150

mm. In attempting to work with the counter at pressures of only 15 mm., it was necessary to increase the sensitivity of the electrometer to such a degree that numerous disturbances interfered with the readings; therefore the rectifier was replaced by dry cell batteries.

Radiation Sources.—Earlier experiments carried out in Leningrad have shown that the oxidation reaction between $K_2Cr_2O_7$ and $FeSO_4$ is a source of radiation which is easily reproducible and which also serves as a characteristic test for the sensitivity of counter tubes to mitogenetic radiation. The apparatus which we used for this reaction is shown in Figure 2. The reaction chamber was entirely closed to eliminate any effects from outside influences, such as vapors. Two long tubings lead from the reaction chamber into two large containers

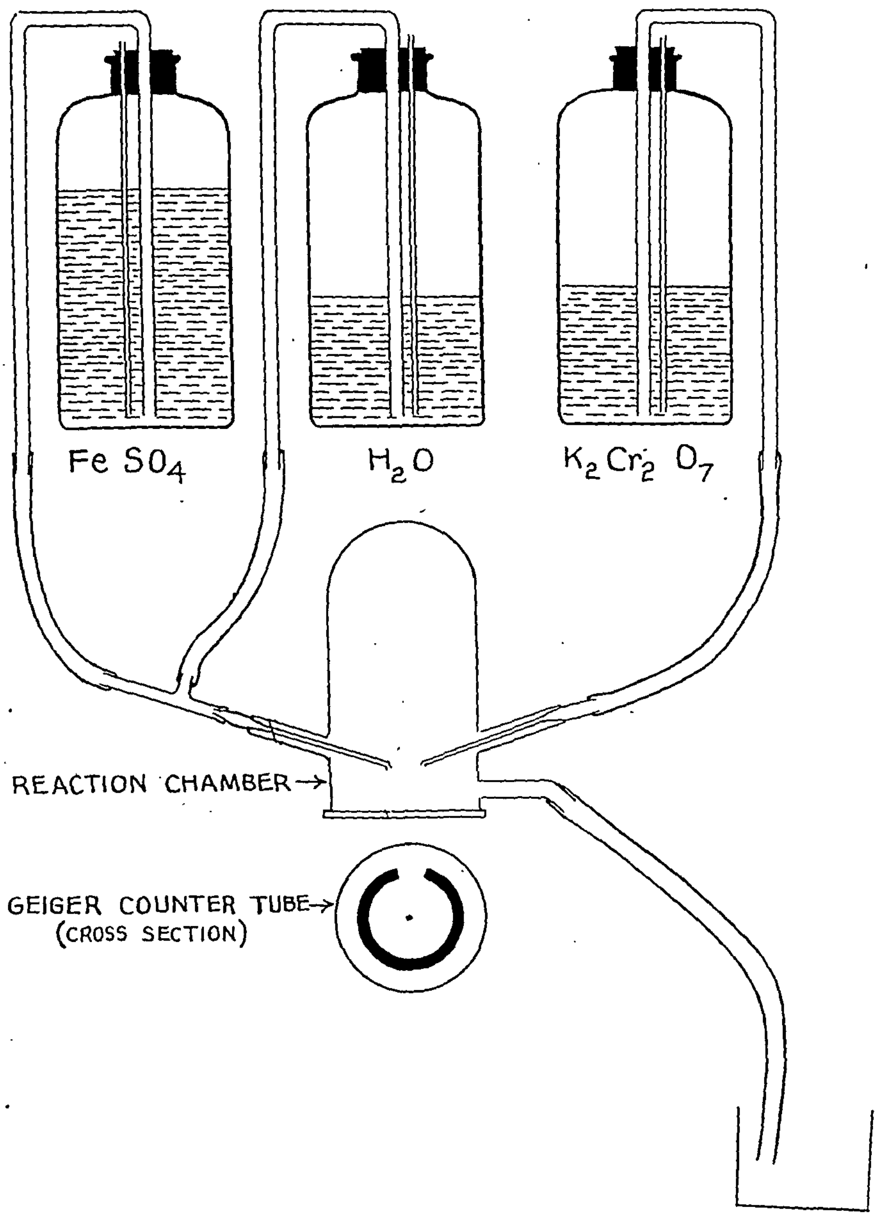

Fig. 2.

which hold the chemical solutions. After the mixing, the solution drains from the reaction chamber into a vessel standing under the table. The stand, contents of the reaction vessel, and bottles were grounded by copper wire in order to avoid electrostatic charges. A third bottle filled with water was used to replace the reaction fluids for control experiments.

TABLE II.—EXAMPLE OF A SINGLE EXPERIMENT

(Time in minutes for 10 counts)

With reaction	Control	Controls made with
1.2	3.3	Cr
2.2	2.2	Fe
1.2	2.0	Fe
2.0	2.2	Cr
1.8	3.0	Cr
1.5	3.0	Fe
2.1	2.8	Fe
1.9	1.8	Cr
2.4	2.0	Cr
2.1	3.2	Fe
Total 18.4	25.5	
Counts Min. 5.4	3.9	Difference = 1.5 = 39%

The reacting solutions were one-tenth normal. The rate of flow of the $K_2 Cr_2 O_7$ solution was regulated with a clamp to two drops per second and that of the $Fe SO_4$ solution to three drops per second (following the suggestion of A. Pototzky). The proportions were carefully controlled and kept constant. Control counts were made (Tables II and V) by stopping the flow of one of the reaction components or by replacing the reacting liquids with water.

In the next chapter we will explain why it was not advisable to make control counts in our laboratory by removing the reaction vessel from the counter window or by inserting a glass plate between the radiation source and counter. We found that all movable articles in this laboratory increased the counting rate when brought near the counter. Control experiments of this type, therefore, are not reliable unless special experiments are made to test the possible radio-activity of all movable articles. We have been unable to carry out a complete study of this phase.

Influence of Radio-active Materials.—The presence of a radium emanation apparatus containing almost one gram of radium in the basement of our laboratory building naturally brought up the question of whether or not contamination of the rooms and equipment with radio-active deposits was responsible for the failure, or at least for the numerous difficulties, encountered in our mitogenetic experiments. It is well known that the counter tubes are extremely sensitive to radio-active materials.

Since a number of counter tubes made exactly alike in the simple manner previously described (2) may show considerable differences in their dark-count rates, it is often difficult to determine definitely to what degree an additional ionization may influence the counting rates of single experiments. However, observations made during some of our first experiments made us suspect that this might occur and interfere considerably with the readings. The counter tube was enclosed in a tube of black paper in order to study the sensitivity of the counter for visible light. Contrary to our expectations, the counter tube then produced a larger number of clicks. The effect was increased when the experiment was repeated in a completely dark room.

Since the dark rate for these counter tubes did not show changes in similar experiments in Leningrad, this peculiar behavior must have been due to a weak radio-activity of the paper which had been stored in our laboratories for a long time. A systematic check of fresh papers proved this assumption to be correct. Data in Table I show that the old paper had a definite effect upon the counter, whereas fresh ones did not show any action beyond the limit of error; it is probable that even the new paper assumed a weak activity after it had been kept in the laboratory for a few days. These disturbances clearly demonstrate the difficulties of a systematic investigation of the mitogenetic radiation in a building housing a radium emanation plant. Unfortunately, we were not able to

transfer our whole equipment to a place where no radio-active influences could be detected. Traces of radio-activity could be found in all of the widely scattered buildings of the Cleveland Clinic Foundation. Although these traces are far below the point of danger to the personnel, they definitely interfered with our mitogenetic work. However, it seemed to us that experiments with the chemical reaction, as described, might permit us to distinguish between the expected effects of ultra-violet radiation emitted during the reaction and the effects due to a weak radio-activity of the reacting liquids.

Experiments.—The experiments in Leningrad had proved that not all counter tubes will show a response to chemical reactions, even though they may be constructed in exactly the same way as those which do. Therefore, we had to determine how many good tubes might be found in a lot built according to specifications and also whether tubes found to be satisfactory in the first experiments remained constant in subsequent tests.

Thirty-three counter tubes were built here and each was subjected to a short test. Table II shows the data obtained in one experiment. The time for ten counts was measured while the chemical reaction took place in front of the counter window: then the reaction was stopped and the count repeated. Readings were thus taken with alternating settings until the total of the dark counts reached about one hundred. It was necessary to confine a single experiment to this number of counts in order to limit the time, although the result is subject to a high degree of statistical uncer-

TABLE III.—COUNTER TESTS

Counter No.	Test No.	Control		Reaction		Counts/ Minutes		Difference		Pressure
		Counts	Minutes	Counts	Minutes	Control	Reaction	Absolute	Percentage	
1	5	220	14.0	220	12.2	15.7	18.0	2.3	15	
2	13	100	6.6	100	8.4	15.2	11.9	−3.3	−22	150 mm.
3	24a	100	9.4	100	8.8	10.6	11.4	0.8	8	
Total		420	30.0	420	29.4	14.0	19.3	0.3	2	
4	44	160	43.7	160	35.0	3.7	4.6	0.9	24	
4a	45	120	53.5	120	46.4	2.2	2.6	0.4	18	
5	48	100	22.3	100	20.5	4.5	4.9	0.4	9	
6	54	130	54.2	130	46.4	2.4	2.8	0.4	17	
7	56	100	22.5	100	14.7	4.4±0.4	6.8±0.7	2.4±0.8	52	
8	59/60	120	34.3	120	24.9	3.5±0.3	4.8±0.4	1.3±0.5	37	
9	75	120	22.6	120	24.5	5.3	4.9	−0.4	− 9	
10	76	170	29.3	170	24.4	5.8	7.0	1.2	17	
11	80	100	19.7	100	19.7	5.1	5.1	0.0	0	
12	81	120	32.9	120	27.2	3.7	4.3	0.6	15	
13	82	110	19.4	110	19.9	5.2	5.0	−0.1	− 3	
14	83	100	43.1	100	39.4	2.3	2.5	0.2	9	
15	85	200	16.9	200	16.0	12.0	13.0	0.7	6	
16	86	120	46.1	120	29.6	2.6±0.2	4.1±0.4	1.5±0.4	56	
17	87	60	10.7	60	6.5	10.7	9.3	−1.4	−16	15 mm.
19	88	80	40.6	80	35.8	2.0	2.2	0.3	14	
20	89	110	28.6	100	29.2	3.5	3.4	−0.1	− 2	
21	90	100	21.8	100	23.4	4.6	4.3	−0.3	− 7	
22	91	100	16.0	100	17.4	6.3	5.8	−0.5	− 9	
23	92	100	18.9	100	17.6	5.3	5.7	0.4	7	
24	94	100	14.8	100	14.4	6.7	6.9	0.2	3	
25a	95a	70	22.4	70	24.2	3.1	2.9	−0.2	− 8	
25b	95b	110	54.0	110	44.2	2.0	2.5	0.5	18	
26	96	100	27.8	100	29.6	3.6	3.4	0.2	7	
27	97	120	35.8	120	25.2	3.7±0.3	4.8±0.4	1.1±0.5	31	
28	98	30	10.2	30	8.9	3.0	3.4	0.4	12	
29	106	100	53.5	100	48.8	1.9	2.1	0.2	10	
30	107	90	34.6	90	23.9	2.6±0.3	3.8±0.4	1.2±0.5	31	
31	108	100	47.5	100	32.2	2.1±0.2	3.1±0.3	1.0±0.4	48	
32	109	100	29.8	100	31.6	3.4	3.2	−0.2	− 6	
Total		3230	923.9	3230	801.0	3.50±0.06	4.03±0.07	0.53±0.094	15.1	

tainty if the effects obtained are rather small.

Table III gives the results obtained with the 33 experiments and shows a total count which exceeds from five to six times the limit of error. Twenty-four of the single tests are on the positive side and nine on the negative. Six of the positive results are over the limit of error twice and two of them three times. All the negative results are smaller than the limit of error except No. 13, which is smaller than twice the error. Judging from the results in this table, we must assume that the radiation

TABLE IV.—REPEATED EXPERIMENTS WITH SINGLE COUNTERS

Counter No.	Experiment No.	Control		Reaction		Counts/Minutes		Difference	
		Counts	Minutes	Counts	Minutes	Control	Reaction	Absolute	Percentage
A. "Sensitive" Counters									
		Reaction $FeSO_4 + K_2Cr_2O_7$							
1	5	120	8.0	120	6.5	14.9	18.5	3.6	24
		100	6.0	120	5.7	16.8	17.6	0.8	5
	6	120	6.2	120	5.0	19.9	24.1	4.2	21
		120	6.5	120	5.7	18.5	21.1	2.6	14
	7	120	5.1	120	5.4	23.5	22.2	−1.3	− 6
	8	100	5.0	120	4.5	20.2	22.2	2.0	10
		100	6.8	100	6.3	14.8	19.1	4.3	29
		100	6.0	100	5.4	16.7	18.5	1.8	11
		100	5.1	100	3.9	19.8	26.0	6.2	31
		100	5.2	120	5.5	23.3	22.0	−1.3	− 6
Total		1100	59.6	1100	52.17	18.4 ± 0.63	20.9 ± 0.56	2.5 ± 0.84	14
5	48	100	22.3	100	20.5	4.5	4.9	0.4	9
	49	140	24.7	140	17.9	7.8	5.7	2.1	37
	50	60	20.8	60	13.2	2.9	4.5	1.6	55
	51	230	65.7	230	57.3	3.5	4.0	0.5	14
	52	100	24.9	100	23.5	4.0	4.3	0.3	8
	53	100	20.9	100	20.6	4.8	4.9	0.1	2
Total		730	189.3	730	153.0	3.86 ± 0.14	4.77 ± 0.16	0.91 ± 0.21	23.5
7	56	100	22.5	100	14.7	4.4	6.8	2.4	53
	58	110	20.5	110	17.9	5.4	6.2	0.8	15
Total		210	43.0	210	32.6	4.88 ± 0.34	6.44 ± 0.40	1.56 ± 0.52	32
8	59/60	120	34.3	120	24.9	3.5	4.8	1.3	37
	63	100	23.9	100	18.2	4.2	5.5	1.3	31
	69	100	25.3	100	18.2	4.0	5.5	1.5	39
	71a	100	20.2	100	19.5	5.0	5.1	0.1	2
	72a	90	18.7	90	16.8	4.8	5.3	0.5	10
	74	100	23.0	100	21.9	4.4	4.8	0.2	5
	73	100	20.6	100	22.6	4.9	4.4	−0.5	−10
Total		710	166.0	710	142.1	4.28 ± 0.16	5.00 ± 0.19	0.72 ± 0.25	17
10	76	170	29.3	170	24.4	5.8	7.0	1.2	17
	77	70	31.5	70	23.3	2.2	3.0	0.8	26
	71	100	49.9	100	47.1	2.0	2.1	0.1	6
Total		340	110.7	340	94.8	3.07 ± 0.15	3.59 ± 0.17	0.52 ± 0.23	17
28	98	30	10.2	30	8.0	3.0	3.4	0.4	12
	99	100	33.9	100	24.4	3.0	4.1	1.1	39
	105	120	41.4	120	40.2	2.9	3.0	0.1	3
Total		250	85.5	250	73.5	2.93 ± 0.19	3.40 ± 0.21	0.47 ± 0.28	16
					Experiments with Blood				
16	100	124	40.0	124	33.6	3.1	3.7	0.6	19
	101	55	27.0	55	21.3	2.1	2.6	0.5	26
25b	102	63	28.0	63	20.7	2.2	3.0	0.8	35
27	103	150	21.3	150	17.7	7.0	8.5	1.5	21
	104	124	28.0	124	22.1	4.4	5.6	1.2	26
Total		516	144.3	516	115.4	3.58 ± 0.16	4.49 ± 0.20	0.91 ± 0.25	25

source investigated had a small but definite action upon our counter.

The average effect, as shown in Table III, is only 15 per cent. It is to be expected, however, that if some of the counters could be tested again, they would show a higher average result, since the single counters would probably have a different sensitivity toward the reaction. Several of the counters which we thought showed a higher sensitivity with the reaction were, therefore, used in the larger number of tests. The results obtained are shown in Part A of Table IV.

In order to find out whether or not a negative result exceeding the limit of error could be obtained in our control experiments, we also made a large series of experiments with counters which seemed to show high negative results. The results of these experiments are given in Part B of Table IV.

The average effects obtained are seen to be between 14 per cent and 23 per cent, as shown in Part A in Table IV. Five of the six results exceed twice the error and three exceed three times the error, while in Part B none of the results exceeds twice the error.

We also started to investigate blood as a radiation source with some of our good counters. The small series of five blood experiments shows a positive total which is greater than three times the average error.

In order to make a further study of the effect, we varied the methods for the determination of the dark rate. As men-

TABLE IV.—REPEATED EXPERIMENTS WITH SINGLE COUNTERS (*Continued*)

Counter No.	Experiment No.	Control Counts	Control Minutes	Reaction Counts	Reaction Minutes	Counts/Minutes Control	Counts/Minutes Reaction	Difference Absolute	Difference Percentage
B. *"Insensitive" Counters* Reaction $FeSO_4 + K_2Cr_2O_7$									
2	13	100	6.6	100	8.4	15.2	11.9	−3.3	−22
	14	100	8.2	100	8.6	12.2	11.6	−0.6	− 5
	15	100	4.9	100	4.5	20.4	22.2	1.8	9
	16	100	5.3	100	4.5	18.9	22.2	3.3	17
	17	100	9.7	100	9.2	10.3	10.9	0.6	6
	18	100	6.7	100	6.5	14.9	15.4	0.6	3
	19	100	8.2	100	7.1	12.2	14.1	1.9	16
	20	120	9.7	120	9.5	12.4	9.5	0.2	2
	21	120	7.8	120	9.4	15.4	12.8	−2.6	−17
	22	120	8.7	120	10.0	13.8	12.0	−1.8	−13
Total		1060	75.8	1060	77.6	14.0 ± 0.38	13.6 ± 0.42	− 0.4 ± 0.57	− 3
3	24a	100	9.4	100	8.8	10.6	11.4	0.8	8
	24b	140	15.2	140	15.6	9.2	9.0	−0.2	− 2
		100	12.2	100	13.4	11.5	10.5	−1.0	− 9
	25	120	12.0	120	12.2	10.0	9.8	−0.2	− 2
		120	11.3	120	10.0	10.7	12.0	1.3	12
		140	12.6	140	11.5	11.1	12.2	1.1	12
	26	100	8.0	100	9.6	12.6	10.4	−2.2	−17
		100	10.3	100	8.0	9.7	12.6	2.9	30
		120	11.6	120	12.4	8.5	8.1	−0.4	− 5
Total		1030	102.7	1030	101.4	10.0 ± 0.31	10.2 ± 0.32	0.2 ± 0.45	2
6	54	130	54.2	130	46.4	2.4	2.8	0.4	17
	55	100	25.8	100	25.1	3.9	4.0	0.1	3
Total		230	80.0	230	71.5	2.88 ± 0.19	3.22 ± 0.21	0.34 ± 0.28	12
14	83	100	43.1	100	39.4	2.3	2.5	0.2	9
	84	80	17.3	80	22.4	4.6	3.6	−1.1	−23
Total		180	60.4	180	61.8	2.98 ± 0.30	2.91 ± 0.29	−0.07 ± 0.42	− 2.4
23	92	140	39.8	140	37.8	3.5	3.7	0.2	5
	93	100	18.9	100	17.6	5.3	5.7	0.4	7
Total		240	59.2	240	55.4	4.06 ± 0.23	4.33 ± 0.25	0.27 ± 0.34	7

tioned previously, the dark rate measurements were made while the reaction chamber was alternately filled with only one of the reaction components or with pure water. These controls should all show the same effect, if the positive observed effects are due exclusively to ultra-violet radiation emitted from the reaction. If, however, the weak radio-activity of the liquids is responsible for part of the effects shown in Tables III and IV, it is to be expected that experiments made with different types of controls would produce different results. Since the amount of liquid in the reaction chamber was the same during the counts with the reaction and during the control, a radio-activity of the liquids could have caused the effects observed only if either the iron or the chromium solution had been more active than the other liquids. Such an effect should have caused a difference between the experiments controlled with the Fe SO_4 solution and those controlled with the K_2 Cr_2 O_7 solution. Since

TABLE V.—SEPARATE RESULTS FOR DIFFERENT CONTROLS

No.	Control ($K_2Cr_2O_7$)	Reaction Minutes	No. Counts	Control ($FeSO_4$)	Reaction Minutes	No. Counts	Control (water) Minutes	Reaction Minutes	No. Counts
A. Experiments with a total effect greater than 20 per cent									
27	11.2	9.7	40	11.6	7.4	40	10.2	8.1	40
28	17.5	11.6	50	16.4	12.8	50	..	..	..
59/60	20.4	13.0	60	13.9	11.9	60	23.9	18.2	100
69	12.2	9.2	50	13.1	9.0	50	..	..	..
86	21.1	11.1	60	22.7	17.2	80	2.6	1.4	10
77	16.1	11.3	30	12.9	10.6	30	2.5	1.4	10
99	16.4	12.8	50	17.5	11.6	50	..	..	..
Total	114.9	79.0	340	108.0	80.5	360	38.9	29.1	160
Counts	2.96	4.31		3.32	4.48		4.12	5.50	
Minutes	±0.16	±0.23		±0.18	±0.24		±0.33	±0.44	
Difference	1.35±0.26 = 46%			1.16±0.30 = 35%			1.38±0.55 = 34%		
B. Experiments with a total effect less than +20 per cent									
71a	10.2	11.2	50	10.0	8.3	50	..	..	..
72a	6.7	6.4	30	12.2	10.7	60	..	..	..
73	11.0	11.8	50	9.6	10.8	50	..	..	..
74	9.9	11.4	50	13.0	10.5	50	..	..	..
75	10.3	10.3	60	10.7	12.6	50	1.8	1.8	10
76	12.3	10.6	80	13.2	9.7	70	3.9	4.1	20
79	7.9	7.8	20	7.8	7.4	20	34.3	32.0	60
80	6.6	9.3	40	9.0	6.5	40	4.0	3.8	20
81	14.8	12.6	50	13.7	9.9	50	4.3	4.7	20
82	4.9	5.8	30	6.5	7.6	40	8.0	6.5	40
83	19.9	19.2	50	23.2	20.3	50	..	..	..
84	9.8	12.5	40	7.4	9.8	40	..	..	..
88	20.1	17.1	40	20.5	18.7	40	..	..	..
89	16.3	14.3	50	12.4	14.8	50	..	..	..
90	11.4	13.6	50	10.3	9.8	50	..	..	..
91	7.7	9.9	50	8.4	6.5	50	..	..	..
92	8.6	8.9	50	10.4	8.7	50	..	..	..
93	19.6	20.2	70	20.2	17.6	70	..	..	..
94	8.7	7.2	50	6.3	7.2	50	..	..	..
95a	15.1	15.8	40	7.4	8.4	30	..	..	..
95b	33.3	21.9	60	20.7	23.0	50	..	..	..
96	14.1	12.8	50	15.5	15.0	50	..	..	..
98	8.7	5.5	20	1.5	3.4	10	..	..	..
105	19.7	20.4	60	21.8	19.8	60	..	..	..
106	25.2	24.1	50	28.3	24.1	50	..	..	..
109	16.3	17.0	50	13.5	14.6	50	..	..	..
Total	348.9	336.6	1240	333.2	315.2	1230	66.3	62.9	170
Counts	3.55	3.68		3.70	3.91		2.57	2.70	
Minutes	±0.10	±0.11		±0.11	±0.11		±0.20	±0.21	
Difference	0.13±0.15 = +4%			0.21±0.16 = 6%			0.13±0.29 = 6%		

the number of counts of any one kind of control in a single experiment is too small to permit a definite conclusion, it must be studied by summation over a series of our tests. Table V-*A* shows the average effects for the single controls of all tests which gave a total result greater than 20 per cent, or, in other words, the results of all tests which show a difference greater than two times the statistical error of 100 dark counts. These experiments should show a positive average result, no matter how the control counts were made.

The same calculations were made for all experiments with a total result of less than 20 per cent. The results are shown in Table V-*B*. The average effect of all partial results in this table should be definitely smaller than the results shown in Table V-*A*. The tables show the results expected. In Table V-*A*, the chromium controls as well as the iron controls showed positive results, namely, 46 per cent, or about five times the mean error for the chromium solution, and 35 per cent, or about four times the mean error for the iron solution. A calculation of the data below 20 per cent in no instance produced an effect which reaches twice the error. So far, the controls made with water agree with those made with iron and chromium. We must therefore conclude that the results of our counter-tube tests are not due to radio-activity of one of the liquids used in the reaction apparatus.

A survey of all the experiments made during the last year, both published and unpublished, has convinced us of the futility of carrying out successfully any mitogenetic work in a building which is infected with radio-active decay products. We have therefore decided to continue our efforts in buildings which are entirely free from any of the effects of such radio-active products.

We wish to express to Mr. I. E. Beasley our appreciation for his helpful assistance in many of these experiments.

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ROENTGEN EVIDENCE OF PULMONARY TUBERCULOSIS IN SUPPOSEDLY HEALTHY INDIVIDUALS[1]

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KOCH, after discovering the tubercle bacillus, remarked that while the attempt had been made again and again to prove, on the evidence of collected clinical observation, that phthisis is contagious, the theory had met with no acceptance by the scientific world.

After he proved that the causative agent is the tubercle bacillus, he said that it was probable that there was no prospect that we could find a therapeutic means of dealing with the parasite within the body, and it would seem that the time had come to adopt prophylactic measures against tuberculosis. This was in 1884.

It seems that now, after 54 years, we have come to realize fully that the primary factor in prophylaxis consists in case-finding, and, when found, locating the source from which the infection was derived. If the second step is not taken, little good can accrue to the general public as a result of finding the new case, for while he or she may not be in an infective stage, the one from whom he derived the infection certainly is and, furthermore, will continue to infect others.

In various parts of the country surveys are being made of large groups of individuals, most of whom are presumably in good health. The results of these surveys show a surprising incidence of unrecognized tuberculosis in those who little suspect they are affected.

The economic problem in carrying out these studies is a very serious one to meet. To obtain co-operation of individuals who believe themselves well is not always a simple matter. If every person should be compelled to submit to a dermal test plus a roentgenographic examination, if reacting positively, the cost and labor involved would be almost beyond calculation. That such a method would uncover the disease in millions of our population is without doubt true, in view of the statistics available. It would not disclose all of the inhabitants suffering from the disease. To be of greatest value, repetition of the test is necessary. Dow and Lloyd (1), describing the study of 500 children, found that of 225 giving a negative tuberculin test 35 per cent had positive findings by x-ray examination. Twenty-two of 51 children that showed calcification of tracheobronchial nodes reacted negatively to the tuberculin test.

It is now believed by some that there is little relation between Ghon tubercles or calcified nodes and the Mantoux test. It would appear desirable, however, best to begin such surveys with the dermal test, not only because of its value *per se* but on account of the low cost of the material used and the facility of applying it to large groups.

Myers, Diehl, Lees, and Levine (2), working in collaboration, describe the results of their examinations of student nurses, by the Mantoux test, from the time of their entrance to graduation. In one school these tests, as applied to the 1929 and 1930 classes, showed 23.08 per cent positive reactors on admission, and 91.23 per cent positive at graduation. This was in a hospital in which there was a tuberculosis division in which each nurse was compelled to spend three months of her training. In another training school, without a tuberculosis division, which admitted an occasional tuberculous patient, the incidence of positive reactors was not as great. The total incidence of 1929 and 1930 classes on entering was 30.51 per cent and on graduating, 37.21 per cent. In the same school, however, the 1931 and 1932 classes showed 20.34

[1] This is one of a series of papers contributed by friends and former pupils of I. Seth Hirsch, M.D.

per cent on entering and 54.35 per cent on graduating.

It is very obvious from these figures that the more contact had with tuberculous patients the greater the increase in percentage of reactors among the nurses, and that some such technic in the handling of tuberculous patients in an infective stage, as is used in handling patients with other infectious diseases, would reduce the incidence among the nurses.

The x-ray, unfortunately, helps only in determining the site of the first infectious type of lesion in a small percentage of the cases. There are many reasons for this, from obscuration by other structures, as heart and great vessels, to location of the lesion in some other part of the body. The re-infection type of lesion, however, is readily demonstrated by x-ray examination at an early stage in its development and when the most helpful treatment may be applied, with great saving in money and time lost from normal activities.

The work reported in this paper is not the result of a planned survey, as will be explained later. Relatively few of the individuals reported herein received the dermal test. We were prompted to this review by the fact that we were more or less incidentally finding tuberculosis with great frequency in presumably well individuals with no known clinical symptoms, who were seeking employment or admission to a training school and who, prior to x-ray examinations, had passed satisfactory physical examinations.

The tendency of employers, hospitals, schools for nursing, and colleges to require roentgenograms demonstrating healthy lungs before the acceptance of workers or students is increasing. In helping to carry out these requirements we have, during the past few years, had the privilege of examining the chests of three groups of individuals who planned to enter a new type of work. The individuals of each of these groups had expressed no knowledge of any current illness and had passed a physical examination satisfactorily before being studied roentgenographically. A review of the roentgen findings in these individuals revealed unsuspected active tuberculous lesions of the lungs so frequently that we believe the summation worth reporting at this time. No attempt will be made to correlate these findings with the general incidence of tuberculosis which varies as to locality, climate, and other factors.

Our studies include a rather large group of young women examined when about to enter training schools in two hospitals of Newark, New Jersey, and one in East Orange, New Jersey. Subsequent examinations were made of those becoming ill during the course of training. Other studies were made of all prospective employees of the Home Office of the Prudential Life Insurance Company, situated in Newark, New Jersey, and employees of

TABLE I.—CHEST X-RAY EXAMINATIONS

(Applicants for Employment, September, 1934, through April, 1938)

	Minimal #	Minimal %	Mod. Adv. #	Mod. Adv. %	Far Adv. #	Far Adv. %	Total Number	Total Percentage
Total Number Examined							4,662	100
Adult Tuberculosis							41	0.88
Probably active	17	0.37	4	0.09	2	0.04	23	0.49
Probably cured	13	0.28	5	0.11	0		18	0.39
	30	0.65	9	0.20	2	0.04		
Other Lung Abnormalities							17	0.37
Total Lungs Abnormal							58	1.24

the Western Electric Company, who were engaged in, or about to be assigned to, the work known as sandblasting.

We recognize the difficulty in describing the healthy chest because of wide normal variations. We like the description given by Wessler and Jaches which is too long to be quoted here. In our work we prefer to consider the ideal healthy rather than the "normal" chest about as follows:

(1) A smooth diaphragm with absence of indications of thickened pleura in the costophrenic angles.

(2) Absence of thickened pleura of the apices; the so-called apical cap.

(3) Vascular markings of normal density and distribution.

(4) Absence of cloudiness in any portion of the parenchyma.

(5) Lack of mottling from nodule formation.

(6) Absence of calcific deposits.

(7) Absence of increased hilus densities.

(8) Absence of healed lesions of any type.

(9) Heart and aortic shadows within normal limits.

One has to decide from experience and the possible hazards of the prospective employment how much attention should be paid to the finding of abnormal shadows in a given individual. For instance, in the absence of any other finding, either roentgen or clinical, should the presence of a single Ghon tubercle or calcification of the peribronchial or paratracheal nodes prevent one's employment in a clerical or secretarial position? At the Prudential Home Office these findings alone are no longer considered sufficient to preclude the employment. In our hospitals they do not prevent admission to the training schools. On the other hand, in evaluating the chests of individuals who run the risk of irritation of the lungs from the inhalation of fine dust particles, as in sandblasting, we have considered the presence of any

TABLE II.—CHEST X-RAY EXAMINATIONS

(Home Office Employees, Including Applicants)

	Number	Percentage
Total Examined (Sept. 1, 1933 to April 1, 1938)	9,301	100
Lungs Normal	8,285	89.1
Lungs Normal, with Calcification	762	8.2
Lungs Abnormal	258	2.8
Applicants for Employment	58	0.6
Home Office Employees	200	2.2
Adult Tuberculosis	196	2.1
Applicants for Employment	41	0.4
Home Office Employees	155	1.7
Other Chest Abnormalities	62	0.7
Applicants for Employment	17	0.2
Home Office Employees	45	0.5

TABLE III.—CHEST X-RAY EXAMINATIONS

Home Office Employees, September, 1933, to May 1, 1938. Non-Tuberculous Chest Conditions

Age Group	Abscess	Tumor Benign	Tumor Malig.	Pneumonitis	Pleurisy with Effusion	Bronchiectasis	Spontaneous Pneumothorax	Miscellaneous
Under 20				1			1	
20–24	1			7	3		5	2
25–29	1	1		6	3	3	3	
30–39				6	1		1	
40–49			1	1			1	3
50–59	1		4	2	2			3
60 and over								
Total 63	3	1	5	23	9	3	11	8

evidence of healed tuberculosis, even of the first infection type, warrants a recommendation that the individual be assigned to a less hazardous occupation.

Technic.—The technic employed is either a 200 ma. for $^1/_{10}$ of a second, or 300 ma. for $^1/_{20}$ of a second exposure in the upright posture, five or six foot distance, with the rays passing in a postero-anterior direction through the sagittal plane. The kilovoltage employed is judged according to the largest anteroposterior diameter of the thorax, and sufficient penetration is produced to visualize the lung markings well out into the peripheral portions of the lungs near the axillæ. Extreme contrasts obtained through the use of low voltages, high milliamperage, and prolonged development at higher than normal temperatures are no longer preferred by us, as it is extremely easy to overlook faint shadows indicating primary lesions with roentgenograms of that quality. The instantaneous Bucky diaphragm is used at four feet, to make supplementary examinations in certain instances, and the rotating anode tube is employed when included in the installation. It has been found that perfect screen film contact is a prime essential in rendering sharpness of detail.

In the year immediately preceding the installation of x-ray equipment at the Prudential Home Office, we examined, at our office, about one hundred of the Company's employees who had seen service for variable periods of time and had developed tuberculosis during employment. In several instances, employees who had been engaged in the service of the Company from five to ten years and who had been absent on account of sickness less than two weeks during that service, were found to have advanced tuberculous lesions in one or both lungs, with cavitation and sputum markedly positive. These individuals had passed satisfactory physical examinations before being employed but up to that time were not required to have roentgenograms made of their lungs. They were entitled to apply to the Infirmary at the Home Office for diagnosis and advice but not for medical treatment. The insidiousness of the onset of this disease and the danger to co-workers, as well as the community at large, when it goes unrecognized, is well demonstrated by these experiences.

The Company, after installing modern x-ray equipment and engaging competent technical personnel and supervision by a physicist, requested us to act as consultants in roentgen studies of the lungs. Although it had been the practice of this, as of other life insurance companies, to aid the employees developing tuberculosis while in their employ by free sanatorium treatment, the problem of caring for affected employees was then freshly attacked in three ways, which include, as described by Ylvisaker (3):

"1. *Pre-employment Examinations.*—Clinical examinations alone are not adequate, as experiences such as the following show:

"A boy, 18 years of age, applied for work on April 16, 1934; passed his clinical examination and when he became ill four months later an x-ray examination showed a far-advanced bilateral pulmonary tuberculosis with extensive cavity formation. His sputum was also markedly positive.

"Those who have had considerable experience in the diagnosis of lung conditions know how difficult it often is to detect early and even more advanced tuberculous lesions without the aid of the x-ray. The statement that early tuberculous lesions are seen, not heard, is very apt and is in agreement with our conclusion that any chest examination which is made for the purpose of eliminating tuberculosis is incomplete without an x-ray film.

"Since Sept. 1, 1934, pre-employment examinations have, therefore, included a single x-ray film of the chest, and during the period up to May 1, 1938, 4,662 applicants for employment have been so examined. Forty-one, a little less than 1 per cent, have shown definite evidence of pulmonary tuberculosis of the adult or re-infection type, with lesions varying from the minimal to the far advanced, and from the definitely active to the apparently cured. Seventeen other chest conditions were also found which required further investigation.

"2. *Periodic Examinations and Examinations Following Illness and Disability.*—Satisfactory as the results of these pre-employment examinations have been, they are not sufficient

Employees, who at the time of their pre-employment examination, are found free from tuberculosis may at any time develop an active lesion. In order to detect these incipient lesions, the Prudential encourages but does not require periodic examinations, urges all employees to consult with their own physician when they become ill and unable to work, and to report back to the Infirmary for a review of their condition before returning to work. Those who have shown any suggestive manifestations of tuberculosis are observed carefully while at work in accordance with any recommendations received from their attending physicians until we feel reasonably certain that there will be no later unfavorable developments.

"3. *Rehabilitation.*—The Prudential does not undertake to treat any of its employees because it feels that this is altogether the function of the attending physician. Its activities have, therefore, been limited to:

"(1) Co-operating with the attending physician in placing these employees in private sanatoria;

"(2) Assisting and encouraging these employees in remaining at these sanatoria until their lesions are healed, until they are no longer infective to others, and until they have been on sufficient exercise to make it safe for them to consider returning to part-time employment;

"(3) Assisting them to return to their former positions, at first on a part-time basis, with later gradual return to full-time employment;

"(4) Close observation after return to work, to make certain that they can continue without endangering their health, that they develop no recurrence, and that they remain free from infection to others.

"From Jan. 1, 1927, to Dec. 31, 1937, a period of 11 years, 157 cases of active tuberculosis have been found among Home Office employees, and most of them have been treated in sanatoria during their period of activity and infectivity. Twenty-three of these have died, a mortality of between 14 and 15 per cent; 22 are still at a sanatorium; seven are still at home; 18 have had recurrences, and 106 have been returned to duty. Of these 106, five have since been retired; 39 have resigned, and 62 are still on duty. Seven of these on duty are still being given pneumothorax by their attending physicians.

"The average sanatorium stay has been a little over a year and seven months and the average total disability one year and ten months.

"We cannot here enter into a more detailed discussion of the work which has been done and the results accomplished. A total of 9,301 employees, including applicants for employment, have been studied in the manner outlined, including x-ray examination, and the results have been analyzed.

"The work is being done as a supplement and aid to that of the attending physician and in co-operation with him, all of us united in the one endeavor—to relieve the individual, for whom we have some responsibility, of a part of the burden imposed on him by tuberculosis."

Our experience in uncovering lesions in nurses, before and after entering the training schools of three hospitals, is as follows:

In the past fifteen years, in the first hospital, only three nurses have died as a result of tuberculosis and one patient with an arrested lesion contracted a fatal pneumonia.

In the years between 1934 and 1938, 104 nurses were examined; of these, 15 had some slight evidence of the first infection type of tuberculosis in calcified hilus shadows or Ghon tubercles. We have not been able to trace the number of dermal test positives, but of the 15 showing calcified nodes, etc., only one has developed active lesions necessitating sanatorium treatment.

Case 1. An adopted daughter was examined by roentgenogram at the time of adoption and was said to have had a healed lesion of the childhood type. She was admitted to the training school and when the time came for her to affiliate with another hospital for special training, she was re-examined and found inactive. When she entered the second hospital another chest examination was negative. She became active during her stay at that institution and her lesion was discovered when she was about to return to our hospital. There was no fatigue or loss of weight and no consciousness of fever, but she was placed in a County tuberculosis sanatorium where repeated sputum tests were negative. The temperature was slightly above normal. Examination of the stomach contents was finally positive for tubercle bacilli. She was kept in the sanatorium for one year and is about to return to duty.

In the second hospital, in 1936, of 31 nurses examined, tuberculosis was found in two; in 1937, 70 nurses were examined and only one case was found; in 1938, 101 nurses were examined and two cases were found. Although the routine entrance roentgenogram is negative, it is possible that the nurse may contract tuberculosis and become infective to others.

TABLE IV.—PRUDENTIAL EMPLOYEES WITH SPONTANEOUS PNEUMOTHORAX IN OTHERWISE NORMAL INDIVIDUALS

Number affected	11
Ages at onset	
Youngest	19 years
Oldest	44 years
Weight	
Lowest	96 pounds
Highest	160 pounds
Previous x-rays available and negative	4
Side	
Right side	11
Left side	8

Other x-ray findings negative excepting one slight exudate in right base.

Clinical condition otherwise negative except one parent died of tuberculosis one year previously.

Follow-up x-rays negative as to tuberculosis in all cases.

Tuberculin test positive in four cases.

Case 2. When giving x-ray therapy one day, the roentgenologist heard from the technician that the nurse accompanying the patient to the department had a bad cough and fever. Her chest was x-rayed and an exceedingly active tuberculosis was found. The sputum was positive. She was treated in a sanatorium and finally recovered.

Of 44 nurses examined in the third hospital in one year, 14 showed positive Mantoux tests, seven showed calcifications either at the hila or in the form of Ghon tubercles, five showed increased local densities of the parenchyma, four showed adhesions to the diaphragm, but none had active tuberculosis. In another year, of 63 nurses examined, 11 had positive Mantoux tests and none had signs of active tuberculosis.

Of the total of 413 nurses examined in these three hospitals, only six cases of tuberculosis were found, or a percentage of 1.45.

While this percentage of tuberculosis in our nurses is regrettable and probably can be lowered, it is much less than the incidence found in other communities. Dow (4) states that among nurses in training this percentage is at least 6 in Canada, a discrepancy in the two localities which points favorably to the care given our own nurses in Newark.

Koch, in 1884, performed the necessary step of isolating from tuberculous lesions the causative organism. The bacillus can be grown outside the body in artificial medium for several generations and the growth from the last transplant will produce typical tuberculosis in suitable animals. It would then seem that the power of controlling the disease consists not only in finding the cases but in isolating them and destroying all of their discharges. Further quoting Koch, numerous experiments have shown that the inhalation of scattered particles of phthisical sputum causes tuberculosis with absolute certainty, not only in animals easily susceptible to the disease but also in those who have much more power of resistance. The tubercle bacillus will survive for a long period of time in dried sputum, so that particles of infected sputum accidently falling on bed linen, the outside of cups, etc., may dry, become pulverized, and be present as dust particles charged with living bacilli in the air to be inhaled by anyone who happens to be present. The factors which determine the conversion of latent infections to manifest clinical disease are fatigue, overwork, malnutrition, and overcrowding. The evidence of Ross and others tends to show that the incidence of tuberculosis among nurses is greater than among women of the same age in other occupations. This point, however, is difficult to evaluate because nurses are more easily available for frequent observation and examination than other groups.

According to a League of Nations report, the death rate from tuberculosis in Germany, in 1913, was 157 per 100,000, and in 1918, after the war, 287 per 100,000.

In Germany at the beginning of the twentieth century, tuberculosis caused 223 deaths per 100,000 or two and one-half times that of four other infectious diseases, *viz.*, typhoid, measles, scarlet fever, and diphtheria. Thirty years later, deaths from the four other contagious diseases had fallen to one-quarter; deaths from tuberculosis had fallen to one-half. Thus, 30 years later, tuberculosis now causes five times as many deaths as the other four contagious diseases put together; not only that, 5 to 15 per cent of the cases of other infectious diseases are fatal, while 60 per cent of open cases of tuberculosis died within three years. Tuberculosis has, therefore, become the major contagious disease problem, especially among young women in the second and third decades.

A rather small number of factory workers was examined for tuberculosis, or other parenchymal changes which might render sandblasting in their cases extra hazardous, but we think it advisable to include them in this report.

These men were all husky-appearing individuals who were under more or less constant medical supervision by a staff of doctors. Those who were assigned to the work of sandblasting were examined to determine whether or not their lungs were impaired to any degree whatsoever recognizable by x-ray examination which presumably would render them more liable to silicosis. On account of their generally robust physical condition, it would not be expected that many cases of active unsuspected tuberculosis would be found. As a matter of fact, however, three individuals of a total of fifty examined were found with sufficiently suspicious positive findings to cause us to recommend that other employment be given them. One of these was suffering from an active pulmonary tuberculous lesion. The others showed signs of healed tuberculous lesions with calcification in the peripheral portions of the lungs.

TABLE V.—EXAMINATIONS AND RESULTS

Year	Employees Examined	First Examinations	Repeat Examinations	Total Examinations	Silicosis	Tuberculosis
1932	11	11	0	13	0	1 (healed)
1933	7	5	2	7	0	1 (active)
1934	10	9	1	12	0	0
1935	9	8	1	17	0	0
1936	17	10	7	22	0	1 (healed)
1937	23	11	12	37	0	0
1938	11	3	8	13	0	0

Those individuals not showing any lung impairment and more or less constantly employed in sandblasting were re-examined from time to time to determine whether or not their lungs were affected as a result of their occupation, as indicated by a chart appended hereto. This indicates that 121 examinations were made of 50 individuals. Twenty-six were examined once, including those with tuberculosis; eight were examined twice; eight were examined three times; one was examined four times; two were examined five times; one was examined seven times; two were examined eight times, and two were examined nine times.

Those free of any pathology showed no increase in the density of the parenchymal shadows during the several years in which they were sandblasting, which may indicate the effectiveness of the protective measures utilized in the plant to prevent the inhalation of dust particles and development of silicosis. One individual developed an enlargement of 7 mm. in the greatest transverse diameter of the heart between the examinations of May and November, 1938. The cause of this is under investigation, but in the absence of any lung lesion it was not believed to be due to the irritation by dust.

DISCUSSION

One of the objects of this paper is to emphasize the unexpected finding of tuberculosis in a large number of supposedly well people who had, immediately preceding an x-ray examination, passed a satisfactory physical examination. We have cited instances in which people have lost little or no time from work for years and yet were, by chance, found to be suffering from tuberculosis of one or both lungs, with cavitation and markedly positive sputum. Six per cent of the healthy male factory workers, examined only because they were about to be transferred to work known to be hazardous, were also found to show signs of sufficient gravity to prohibit the transfer to the new work.

It is probable that more than 1 per cent of our readers, although considering themselves well, would be discovered to have either tuberculosis or some other serious lesion in their lungs if they submitted to an x-ray examination. This opinion has been forced upon us by the records of the Prudential Insurance Company and our own observations since Sept. 1, 1934. Inasmuch as the greatest good and the most rapid cures are made only when the lesions are discovered in their earliest stages, we must take an active part in urging even those who feel well to occasionally submit to an x-ray examination of the lungs. This becomes more urgently necessary if a person has frequent colds or feels tired to an unusual degree without known cause. The general practitioner can do more in this matter than the specialist, for he is ordinarily the one to first contact the patient. The roentgenologist can examine only those referred to him for the purpose, but he should, when opportunity offers, keep other physicians reminded of the insidious onset of this dread disease. Also, that in very early lung involvement the roentgenogram produces evidence which is often pathognomonic and indisputable, and the early diagnosis aids in reducing the mortality and morbidity of this centuries-old scourge.

SUMMARY

1. The general incidence of tuberculosis is not considered in this paper.
2. About 1 per cent of those who considered themselves well and whose lungs were x-rayed, were found to have active pulmonary tuberculosis or some other pathology.
3. A small group of 50, working at sandblasting over a five-year period and using protective masks, etc., did not develop any demonstrable lung pathology as a result of the extra hazard.
4. The public health would be better protected if lungs of "healthy" persons were periodically x-rayed.

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THE ROENTGEN DIAGNOSIS AND TREATMENT OF CARCINOMA OF THE LARYNX AND PHARYNX[1]

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CANCER of the larynx, next to cancer of the skin, breast, mouth, and uterus, gives to us probably the greatest hope of cure with our present knowledge, providing the diagnosis is made early and the lesion is treated skillfully and thoroughly from the beginning. The diagnosis in its earliest and most curable stage is probably not best made by the roentgen rays. The earliest diagnosis I believe can best be made by direct or indirect laryngoscopy. This requires that the patient be brought under the supervision of a skillful laryngologist or bronchoscopist at the onset of the symptoms. The earliest symptoms are hoarseness or local discomfort. These may or may not be associated with pain, soreness, or tenderness. It should be our aim, therefore, to have these patients obtain this expert opinion by the end of two weeks if there is no improvement during this time. Intermittent hoarseness may be due to carcinoma. It is well known that if the diagnosis is made while the lesion is still intrinsic, and the patient is operated upon skillfully, as high as 85 per cent of the intrinsic group has been reported as cured by laryngofissure (Jackson and Jackson, Tucker, Clerf, Gluck, Sorenson, and others).

Tucker, in a study of 200 consecutive cases of carcinoma of the larynx, estimated that at the beginning, 72 per cent were intrinsic, and, therefore, operable. However, as patients now come to the expert laryngologists, the great majority has become extrinsic. Of 280 cases *operated* upon and reported by Nager, Schinz, and Zuppinger, only 23 (8 per cent) were recorded as intrinsic. This would represent a much lower percentage if the inoperable cases are included. Of the 280 cases operated upon, only 11 survived operation from one to nine years (4 per cent). Of these 11 recovered cases, six were classed as intrinsic. Of the cases treated by irradiation (involving a more advanced and usually inoperable group), about 25 to 28 per cent should recover. On this point, Chevalier L. Jackson, in a personal letter, says, "Between the years 1930 and 1937, we saw 347 cases of cancer of the larynx. Of these, 71 (11 per cent) were thought to be of the very early and limited intrinsic sort which are regarded as suitable for the conservative operation of laryngofissure. An additional 79 were operated upon by laryngectomy, but some of these cases were not really suitable cases for surgery, perhaps." Jackson and Jackson find more and more indications for treatment by irradiation, and say, "The greatly increased efficiency of irradiation indicates that laryngectomy should now be limited to good surgical subjects of good general expectancy." In this small early group of cases, therefore, it is not likely that the radiologist will be needed for either diagnosis or cure. It is possible, however, to cure even the early cases by irradiation (Schinz, Stewart-Harrison, Torrigiani, and Palumbo), but it is probably not the most economical nor the most efficient method of treatment. Unfortunately, the great majority of patients do not reach the expert laryngologist or bronchoscopist in this early stage, and then the diagnosis and the differential diagnosis becomes more difficult and the problem of treatment more complicated and more serious. No special method of treatment and no special technic can make up for the disadvantages of late

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[1] This is one of a series of papers contributed by friends and former pupils of I. Seth Hirsch, M.D., who has himself written, in collaboration with S. M. Baum, an excellent article on "Roentgen Diagnosis and Treatment of Laryngeal Neoplasms." *Laryngoscope*, St. Louis, 44, 144–166, February, 1934.

diagnosis and late treatment. Remarkable advances have been made in the radiological treatment of carcinoma of the larynx even in the later stages, but the best results obtained in the later stages are not one-third as good as those obtained while the disease is still intrinsic.

Roentgen Diagnosis.—The skillful roentgenologist can furnish valuable information in all cases of carcinoma of the larynx, but in those cases in which the disease is no longer confined to the cords, and in those cases in which the disease is no longer in the earliest stage, a roentgen study is absolutely necessary. The laryngologist can see the surface of any tumor but a skillful roentgenologist can show usually the outline of the entire tumor and can furnish considerable information as to the conditions of the surrounding tissues. The movements of the larynx and the swallowing function and their disturbance by infiltrating carcinoma can be best determined by the roentgenologist. Pancoast and Pendergrass deserve credit for an excellent description, in 1930. A fluoroscopic study is, therefore, absolutely necessary, as well as roentgenograms. A roentgenogram should be made laterally with the tissues relaxed, then one should be made with an obstructed forced expiration (made with patient's nostrils and mouth closed). The patient should then be given a level teaspoonful of a concentrated barium mixture (Rugar is satisfactory). This can be moved about the mouth and then swallowed, so as to fill all crevices and lateral spaces. A film

Fig. 1. Shows carcinoma involving the arytenoid region, the laryngeal vestibule, the ventricle, the cord, and posterior portion of the larynx, causing an opacity in the posterior two-thirds of the larynx, indicated by small arrows. Lateral view made before radium and x-ray treatment.

Fig. 2. Shows the same case eight months later, with complete absence of all evidence of disease—normal. Notice the complete transparency of the laryngeal vestibule, the smooth outline of the arytenoids, the smooth normal appearance of the ventricle, the smooth vocal cord, and, in fact, everything normal. These normals are as follows: 1. epiglottis; 2. valleculæ; 3. aryepiglottic fold; 4. laryngeal vestibule; 5. arytenoid; 6. pyriform sinus; 7. ventricle; 8. vocal cord; 9. cricoid; 10. trachea.

should then be made laterally, with the tissues in a relaxed position. Then one should be made with the tongue pushed forward as far as possible and held between the teeth. Another film should be made in the postero-anterior direction so as to obtain the view of the filling of the valleculæ, and additional information can be obtained with regard to the cords and ventricular spaces and pyriform sinuses. This position is especially valuable in a study of a tumor of the pharynx, pyriform sinuses, or upper end of the esophagus. If there is a lesion in the pharynx or upper portion of the esophagus, it is an advantage to make several films in the lateral view during the act of swallowing. This is best done with a high milliamperage outfit (500 to 1,000) so as to make the film at a distance of from six to eight feet in a thirtieth of a second. It is always an advantage to make the films at the greatest distance possible, with the shortest time of exposure, and the finest focused tube possible, in order to obtain the greatest amount of detail.

The lateral projection (Figs. 1 and 2) is especially valuable in the study of the transparent areas of the pharyngeal vestibule, the laryngeal vestibule, and the larynx, including the epiglottis, the ary-epiglottic fold, the arytenoids, the true and false cords, and the space between the cords called the laryngeal ventricle. Barton Young describes this space as being "Zeppelin-shaped or cigar-shaped during the phonation 'e,' and is bounded above by the false and below by the true vocal cords." These ventricles and the tissues in the upper pharynx are best shown in a film made with obstructed forced exhalation.

This subject has been well discussed by a number of authors, but particularly by Hay and by Young. Especially when dealing with tumors involving the pharynx, it is important to take into account the soft-tissue space located posterior to the larynx and trachea. This space has been well studied in normal subjects by Hay and tabulated by Young. It should be kept available for constant comparison, as is shown in Table I.

TABLE I.—UPPER NORMAL LIMITS OF SOFT-TISSUE SPACES OF NECK

Age	Post-pharyngeal Soft Tissue	Post-laryngeal Soft Tissue	
0.1	1.5 c[2]	[illegible] c	
1–2	.5 c	1.5 c	
2–3	.5 c	1.2 c	Post-ventricular
3–6	.4 c	1.2 c	
6–14	.3 c	1.2 c	
	Male 0.3 c Female 0.3 c	Male 0.7 c Female 0.6 c	Post-cricoid

[2] c is anteroposterior dimension of fourth cervical vertebral body measured at its middle.

Figure 2 is a composite illustration of a normal neck and soft-tissue spaces, and together with Table I (May) will be found useful for reference in making roentgenograms of the neck, when in doubt as to the normal. (PP) represents post-pharyngeal soft tissue, usually measured at a higher level than shown here. (PC) is the post-cricoid soft-tissue zone (Young).

Anteroposterior Study.—The value of the anteroposterior study (Fig. 3) or the postero-anterior study of the larynx and pharynx has been, I believe, greatly neglected. Young deserves a great deal of credit for demonstrating the advantages of this position, which is valuable both for roentgenograms and for fluoroscopic study. During fluoroscopic study, one may observe the movements both laterally and postero-anteriorly during phonation and during the act of swallowing. Disease will often cause lateral deviation of the food passage and in the lateral view any displacement or distortion of the normal passage anteroposteriorly can be observed, and, of course, can be recorded on the roentgenogram. If one will familiarize himself with the fluoroscopic observation of the movements of the cords in the postero-anterior view and in the lateral view and the movements of the larynx, as well as symmetrical filling of the crevices about the larynx, it becomes more easy to recognize any defect or fixation which is due to carcinoma. The postero-anterior

view is especially valuable because of the possibility of comparing one side with the other. If these cords approximate well and move equally, there, of course, is no fixation and probably no infiltration present. Likewise, if one gives an opaque mixture, the filling of the vallecular recesses and pyriform sinuses can be visualized, and then can be recorded by instantaneous roentgenography on the photographic film. Tomography will give additional information.

Carcinoma of the larynx is usually suspected when there is pain, swelling or soreness, or difficulty in swallowing, or when the patient expectorates blood. Nearly all of these symptoms indicate a rather advanced lesion. It is common for a patient to complain of sore throat, and certainly one does not think of malignant disease every time a patient develops sore throat. Most of these "sore throat" cases are due to inflammation of the tonsil or an inflammation of the pharynx or larynx, but when the symptoms continue during two or more weeks without any improvement, it is wise for the physician to think of the possibility of newgrowth. This is particularly true when the symptoms are located on one side, for, as is well known, tonsillitis commonly affects both sides and a pharyngitis is more or less general. A localized pain, swelling or soreness, therefore, must make one think of some disease which gives a local effect, naming particularly malignant diseases, syphilis, and tuberculosis.

The upper pharynx can be examined completely by the laryngologist, and certainly his studies of the nares, the posterior nares, and the upper pharynx are more conclusive than the roentgen studies. However, when once the laryngologist has made a report on a carcinoma involving these upper pharyngeal areas, the roentgenologist still can add considerable information by determining the upper and anterior limits of any tumor. It is important for the roentgenologist to determine whether or not the tumor has extended up into the sphenoid, ethmoid, or upper nasal passages, and whether or not it has extended into the maxillary antrum. In these cases, too, he can determine to a considerable extent the degree of infiltration as judged by the mobility permitted of the pharyngeal muscles. When a lesion involves the lower pharynx or upper esophagus or the laryngeal area, the roentgenologist can furnish very valuable information, for while the laryngologist can examine the upper surface of the tumor in these regions, it is often impossible to see the lower limits of the disease. Generally, the laryngologist or bronchoscopist demands all the information possible from the roentgenologist before he attempts bronchoscopy or direct laryngoscopy. Tomography is especially useful in outlining the disease below the cords in the transverse plane.

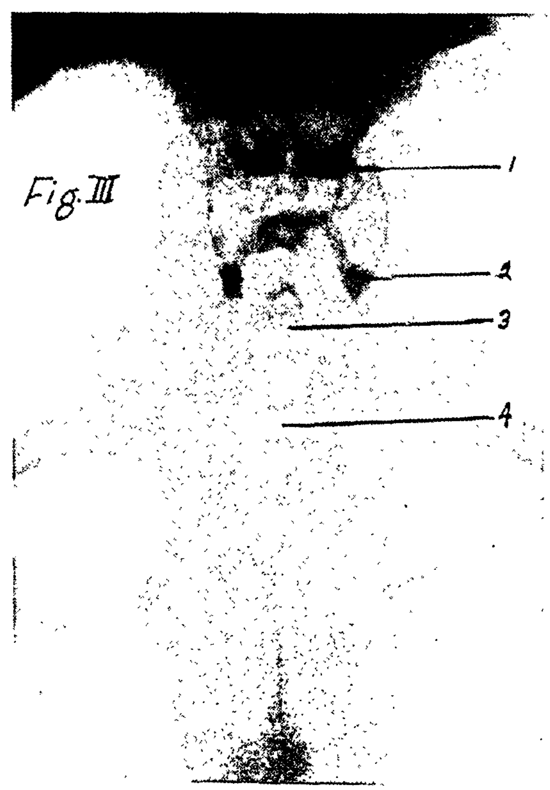

Fig. 3. Postero-anterior view of the larynx; 1. Valleculæ—unequal filling, irregularity in outline, displacement, indicates disease. 2. Pyriform sinuses—they may fill unevenly or there may be filling defect, usually due to tumor; they may be displaced in relation to the median line. 3. Vocal cords—these can be observed fluoroscopically and during phonation, one can observe the free mobility of the normal or the fixation of the diseased cord. 4. Transparency due to the air in the trachea.

Malignant disease involving the lower pharynx or the upper esophagus gives difficulty in swallowing and involves both pain and actual mechanical difficulty in the passage of the food over the tumor. A lateral view in such a case, taken before giving any opaque material, may show an increase in the shadow of the soft tissue involving the post-pharyngeal and post-laryngeal space. The administration of a dense opaque barium mixture will then outline more clearly the lumen of the lower pharyngeal space and the upper esophagus, and will commonly show irregularities of the outline of this space as compared with the normal smooth surface. The postero-anterior view, both fluoroscopically and in roentgenograms, will show the irregular outline of any tumor tissue. The barium is apt to settle into the small crevices which outline the tumor and thereby outline the details of the tumor. If one is prepared to make instantaneous roentgenograms in the lateral view during the act of swallowing, the actual lumen of the esophagus in this region can be determined. If the patient is placed in the right anterior oblique prone position and on a tilt table which permits the head to be at a lower position than the lower part of the esophagus, it is, at times, possible to outline the lower border of the tumor in the esophagus as well as the actual lumen.

Cancer of the larynx is recognized roentgenographically by the opacity which it causes in the transparent laryngeal space. This may be seen at times fluoroscopically but is usually seen more clearly in the roentgenograms, providing fine detail is obtained. In addition to this, one can observe irregularities in even an early case on the two sides of the larynx by irregular filling of the valleculæ or the pyriform sinuses, and one can observe irregularities in the action because of the infiltration, fixation, and increased opacity of the tumor tissue involving the pharyngeal vestibule or the laryngeal vestibule. The tumor may originate in or extend to the vallecular space or the pyriform sinus, in which event it would displace or prevent the opaque material from finding its way into this space. As previously indicated, a tumor of an infiltrating character is apt to fix certain parts of the laryngeal tissues or the larynx itself and interfere with the normal movements of the larynx. Likewise, if a tumor originating primarily either in the larynx or in the pharynx has infiltrated any of the muscles, the movement of these muscles is interfered with, or a tumor involving one or both of the arytenoids may cause an increase in volume, or, if it is in an advanced ulcerating stage, it may show destruction of one or both of the arytenoids. The disease may involve the epiglottis or the aryepiglottic folds which would then not only interfere with the movement of the epiglottis but would also show an irregularity in outline. The space between the epiglottis and base of the tongue is normally smooth in outline, but when ulcer or tumor is present this outline is disturbed and can be easily recognized.

Roentgenograms made at the beginning of treatment serve as permanent records and can be used for comparison later as the case progresses toward recovery under radiation therapy.

Indications for Radiological Treatment.—The radiological treatment of carcinoma of the larynx and the pharynx must be individualized. Therefore, an accurate diagnosis by the laryngologist or bronchoscopist, combined with most careful studies by the roentgenologist, is absolutely essential as the first step to be taken in the treatment and management of tumors located in these regions. In the earliest stages, the laryngologist or bronchoscopist must determine the exact location of the disease, its extent, the mobility of the vocal cords, and obtain what information is possible as to the mobility of the surrounding tissues. He must do a biopsy, either immediately or after a few preliminary x-ray treatments. When these tissues have been examined carefully by a skillful and well-informed pathologist, the general characteristics of the tumor can be determined and a reasonable estimate can be

made by the pathologist as to its radiosensitivity which he will probably grade as I, II, III, or IV, the fourth grade being the most malignant and usually inoperable. This estimation of the radiosensitivity made by the pathologist is helpful but it must not be accepted as the final word. If the pathologist estimates that the tumor belongs to Grade I or II, and the case is still in an operable stage, this evidence will favor operation, but if the disease has extended beyond the operable stage, or if there are contra-indications of a general character to operation, the patient must not be condemned to die without an effort to treat this disease by irradiation. On the other hand, if the pathologist grades the tumor as III or IV, and the disease has extended to the doubtfully operable stage, then this evidence would favor radiological treatment in preference to surgery. New and Waugh obtained no five-year recoveries in the six operable cases belonging to Grade IV. It is my opinion that all borderline operable cases should have a moderate amount of preliminary x-ray treatment before operation, because pathologists have found that while the general characteristics of the tumor, as studied microscopically, point toward one of these four grades, there are likely to be some of the cells belonging to Grade III or IV in the tumor, or at the border of the tumor, which may not be seen in the microscopical specimen, and the presence of these cells may lead to failure. Preliminary irradiation will likely devitalize the more malignant cells, thereby placing the case more definitely in Grade I or II, and, I believe, improve the end-results of operation.

I would estimate that from 900 to 1,200 r units delivered into this tumor tissue preceding the operation would delay the operation probably only one or two weeks, and would be more likely to be followed by permanent success. It is also my opinion that when dealing with an advanced carcinoma, it would be advisable to give such preliminary irradiation before doing a biopsy. This view is also held by Webster. All experienced radiotherapists have found that at times an advanced intensive infiltrating or radioresistant tumor responds to irradiation when, on theoretical basis, it was estimated that there would be little or no response. This determining factor has not yet been discovered. Coutard, in a masterful analysis of his five- and ten-year results in his most recent communication, has tried to determine the likelihood of response to irradiation. He has found that the supraglottic tumors are frequently accompanied by adenopathy, while those of the vestibule or ventricular cavities are more rarely accompanied by adenopathy, and those of the glottis are never accompanied by adenopathy. He also states, "We now know that cancers of the undifferentiated cells, extremely fragile, can be cured by all varieties of irradiation, while cancers of very differentiated and infiltrating cells are only exceptionally cured."

He says further:

"If, for example, the hemilarynx is totally immobile, if the muscles are infiltrated by the neoplasm, if the arytenoid cartilage is totally fixed, the radiosensitivity is low, the possibility of cure is reduced. One thus has generally a very differentiated cancer.

"If, on the contrary, the muscles remain free, if the cords, bands, and arytenoid cartilages have only a slightly reduced mobility, then even if the tumor is voluminous, necessitating a tracheotomy, and has destroyed part of the thyroid cartilage, it is possible to obtain a cure in a great many such cases. These are, in general, cancers formed of only slightly differentiated cells, and more often of mucous membrane type."

He calls attention to the fact that the neoplasm as a whole may seem mobile but may be infiltrating at the point of origin, which can be appreciated only from fifteen to twenty days after beginning treatment. This illustrates the necessity of constant co-operation of the laryngologist (unless the radiologist is especially trained, Webster) in observing these cases during treatment. Dividing the cancers into anterior, median, and posterior, Cou-

tard has found that the median are more easily curable, the anterior area are less often curable, while the posterior group are rarely curable by irradiation.

Technic of Radiological Treatment of the Larynx.—When one thinks of technic in relation to the treatment of carcinoma of the larynx, the Coutard technic naturally comes to mind, but the Coutard technic is not a definite procedure. Dr. Coutard has been varying his technic almost continuously during the past 15 years, both in general management and in its application to the individual case. All radiologists look upon him as a leader and appreciate his contributions and his frank, sincere, and scientific investigation of the problems connected with the treatment of carcinoma of the larynx. The casual reader, however, would get the impression that the Coutard technic is a definite procedure and is somewhat similar in its application to that which is used in radiography, in which we can use a certain number of milliamperes at a certain distance, with certain voltage, for a certain time, in relation to the variable thickness of the part examined, and our photographic effects will be almost uniform.

The treatment of carcinoma of the larynx is a very complicated procedure and while Coutard has developed or has continued the development and study of prolonged fractional dosage, the factors as to unit dosage, total dosage, interval, number of applications, portals of entry, and filtration have been very variable and from a recent communication from him there has been considerable variation, even since his last publication.

The general principles governing the treatment of carcinoma of the larynx, as well as carcinoma elsewhere in the body, are:

1. There should be given sufficient dosage to destroy the cancer cells.
2. The dosage should be given in such manner that it will destroy the cancer cells without destroying the normal tissues.
3. The treatment must be given in a period of time short enough to prevent the development of radioresistance on the part of the cancer cells.
4. The treatment must be prolonged and given in such dosage that it will not seriously damage the normal tissue.
5. The normal tissues must be conserved in every way possible, and the portals must be large enough to cover all disease, but should not greatly exceed this area.

The various authors have been trying to combine these principles along the lines of variable theories. This has led to the many so-called "modified Coutard technics." In practice, the Coutard technic differs little, if at all, from the so-called "saturation technic" which I have utilized and described previously. Both involve prolonged fractional dosage, with a gradual build-up to the limit of normal-tissue tolerance, and, in actual practice in my own hands, has differed very little. In actual practice, previous to Coutard's work, I did not carry my treatment to the extent of a definite destructive epithelitis which I now think is usually necessary but undesirable.

1. To bring about destruction of the malignant cells, it would be desirable to apply the irradiation in the shortest time possible. This, however, endangers the normal tissues, as a general rule. When the cancer cells are of the radiosensitive type, which means that they are undifferentiated, a much lesser dosage is needed to destroy them, and, therefore, the treatment can be given in a shorter period of time, and it is probably desirable to give this treatment in a short time. As the cells become less and less differentiated, such as one finds in Grades III, II, and I, they resemble ultimately in their resistance, the normal tissue cells. One must, therefore, prolong the irradiation so as to make use of a slight differentiation between the normal and the diseased cell. This slight differentiation is due to the fact that the normal-tissue cells have a better organized blood supply which brings about more rapid and complete repair of the damage done by smaller doses continued over a

longer period of time. The cancer cells, on the other hand, having a less well organized blood supply, have less chance of recovery from the damage done by the same relatively small doses given over a prolonged period.

It is also well known that malignant cells are more easily destroyed during the process of division. Therefore, if the radiation is given even though in small dosage at the time of cell division, destruction is more likely to take place. This has led Coutard to recommend low intensity dosage, and he aims to give not more than five or six r per minute. I have attempted to reach this same objective by the use of radium packs, not given during a few hours, as is used with the radium bomb (Edling), but given by packs applied continuously during the entire 24 hours. I have had some satisfactory results in patients treated entirely by such radium packs. This represents the ideal method of applying a prolonged continuous treatment, whereby one obtains the greatest differentiation between the sensitivity of the normal tissues and the diseased tissue.

2. In our effort to destroy the cancer cell without doing serious damage to the normal-tissue cell, the continuous application of irradiation from a radium pack during 24 hours furnishes the ideal method. I have made such continued applications for as long as four weeks, alternating from the right to the left side of the neck. It is my opinion, and it has been the observation of other clinicians, that there is an increased differentiation in the effect upon the cancer cell as compared with the normal-tissue cell, as one makes use of shorter and shorter wave lengths, such as is obtained by increased filtration with radium. It has been my custom, therefore, to utilize two millimeters of platinum filtration, which is the equivalent of four millimeters of lead. This enables one to utilize only the hardest (86 per cent) of the gamma rays. Thus by combining the continuous irradiation, with the object of destroying the cancer cells during the process of division, and by using the higher filtration, there is greater differentiation in the effects between the normal tissue and the diseased tissue. The objection to the use of radium is the relatively smaller depth dose due to the short distance, as compared with the greater depth dose obtained from highly filtered roentgen rays, which can be used at a greater distance. It is fortunate, however, in the treatment of carcinoma of the larynx, that we have only about three and one-half to four centimeters depth dose to the median line, and, therefore, to the central portion of the larynx. Consequently, it is not difficult to get an efficient dosage at this depth, due to the advantages described heretofore. One can further protect normal tissue in relation to the cancerous tissue by utilizing as small a field as possible. The use of small fields has also been emphasized by Martin. This, of course, requires accurate diagnosis as to the extent of the disease, both primary and any secondary disease that may be present. It also gives a tremendous advantage when one can treat these lesions in an early stage, because one can utilize a smaller portal. It is my aim, therefore, to utilize as small a portal as is possible to cover the total area of known disease. This preserves the normal tissue and increases the relative destruction of the cancerous tissue.

3. In choosing a technic with the object of destroying the cancer cells before sufficient time has developed for radioresistance, one must individualize, to a great extent according to whether or not infection is associated, and according to whether or not there is danger of edema, which would lead to closure of the glottis, demanding a laryngotomy. This thought again favors the use of radium at the beginning, because a gradual and safe effect is obtained. I have never seen any suggestion of such edema having been produced by the radium applications. After from four to ten days of continuous application of radium, it is probably desirable to give the high voltage or supervoltage x-rays, highly

filtered, utilizing the right and left posterior cervical portals, posterior to the portal used for the radium, thereby getting an increased effect upon any glandular distribution, and, at the same time, bringing about a greater depth dose by cross-fire upon the laryngeal tumor. This helps to overcome the objections of massive doses at the beginning, and yet accomplishes the desirable results with regard to sufficient dosage within the first two weeks. Recently, therefore, my technic has been to give about half of the total irradiation with the radium packs, and the other half with high voltage or supervoltage roentgen rays. I think no one can lay down any rules. It is a matter of skill and judgment. In general, it is my present impression that if this treatment is varied so as to utilize the radium packs half of each week and the roentgen rays during the other half, it will probably bring about the best results.

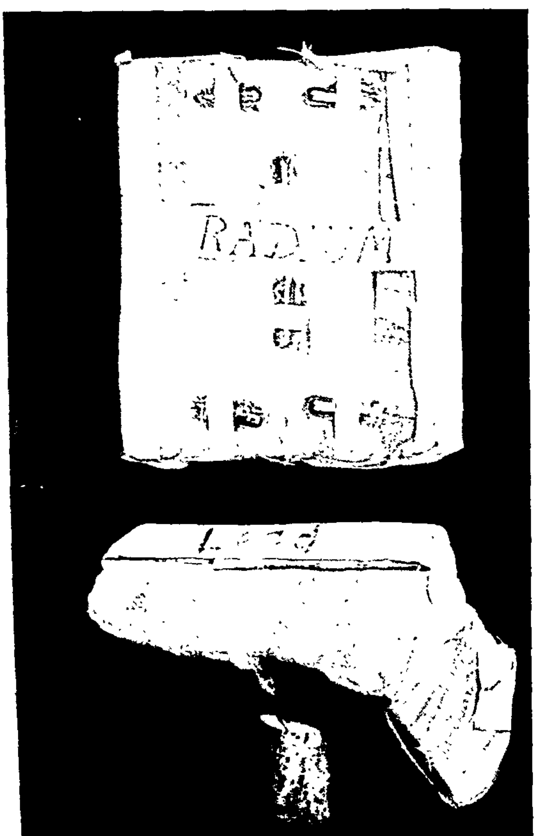

Fig. 4. Upper photograph shows the arrangement of the radium with two 10 mg. units at each end and 3 mg. units underneath the lead covering. This is then placed transversely at the site of the neck overlying the disease. Lower photograph shows the same pad tilted on a cork showing the increased thickness of 1 cm. anteriorly.

4. The combination of radium packs with roentgen rays, as suggested in the foregoing paragraph, and as described in detail, subsequently, enables one to prolong the irradiation safely during a period of six weeks. Coutard has found by his careful analysis that, in general, this is the best period for the optimum results. It must be borne in mind, however, that with the more sensitive types of tumors, the irradiation can sometimes be given to advantage within from two to four weeks. Safety in this period of time lies in the fact that the total radiation need not be so great as is necessary when dealing with the highly differentiated type of tumor.

Radium Pack.—The radium pack was originally made up in the form of a cast fitting the neck, using the Columbia Paste, as recommended at the Curie Institute. This was cumbersome, stiff, and more or less of a burden for continuous wear over long periods. I therefore developed a felt pad, measuring 4 cm. in thickness posteriorly, and 5 cm. anteriorly (Fig. 4). This is fitted in such manner that it makes the distance from the median line of the body to the radium approximately the same both anteriorly and posteriorly. It is estimated, therefore, that approximately the same amount of radiation will reach the sagittal plane extending directly through the middle of the larynx both anteriorly and posteriorly. This pack measures 8 cm. vertically, and 10 cm. anteroposteriorly. When dealing with an early or localized lesion, it will be an advantage to utilize a circular pad from 6 to 8 cm. in diameter (Fig. 5). This can be made up with a cover of 3 mm. of lead and a rim of lead 3 mm. thick extending toward the skin 2 cm., which will partially control stray irradiation and will permit a considerable increase in the total local dosage. On the outer surface of this pack, we usually distribute ten 10-

milligram tubes, each measuring 20 mm. in length and 5 mm. in diameter. The radium is filtered through 2 mm. of platinum, and these tubes are placed two on each edge, approximately 1 cm. from the border, and two in the middle to partially control the irradiation upward toward the face and downward toward the clavicle. I have used an angle of 3 mm. of lead over the upper and lower borders, so as to protect the tissues above and the clavicular region below. Sufficient cotton is placed about the lower border so as not to irritate the clavicle. Arranged in this manner, this radium pack gives 25 r per hour at the contact surface with the skin. At 3.5 cm. in depth—the median line and tumor depth—it would be approximately 10 r. Edling uses 1,250 mg. bomb with only 2 mm. lead equivalent, with which he estimates 40 per cent at 3.5 cm. depth. I have 1,250 milligrams of radium but prefer to use this smaller quantity so as to get continuous irradiation. His surface intensity is, therefore, nearly ten times as great (35.5 Imc.).[3] The patient's head and neck are bandaged so that the adhesive plaster can be applied without irritating the skin. The pack is then bound firmly with adhesive strips running around the neck and with strips over the head. The pack is applied for 24 hours on one side of the neck, and then for 24 hours on the opposite side. The patient is confined to his room but not to bed. The number of applications vary somewhat with the conditions present, both with regard to the patient's physical condition and to his living circumstances. Sometimes the radium is applied for from six to eight hours daily and he is treated in conjunction with the high voltage x-rays. We aim to make from 12 to 16 such radium pack applications for the reasons discussed above. This is supplemented on intervening days with applications of high voltage or supervoltage x-ray treatment, until the estimated amount of irradiation required has been given. After about four weeks, there is very definite redness and desquamation in the epithelium of the skin, and a deep reddish or whitish appearance of the mucous membrane. It is my opinion, however, that there is less damage to the skin and a less violent reaction in proportion to the radiation effects given in this manner, than when the irradiation is given entirely by means of the roentgen rays.

The surface dosage with the radium pack amounts to from 28,000 to 36,000 milligram-hours. The dosage with 200 kv. roentgen rays, filtered through 2 mm. Cu and 2 mm. Al, or the equivalent Thoraeus filter, amounts to from 3,000 to 4,000 r units, given at the rate of 14 r per minute and 250 r per day.

Results of Treatment.—The treatment

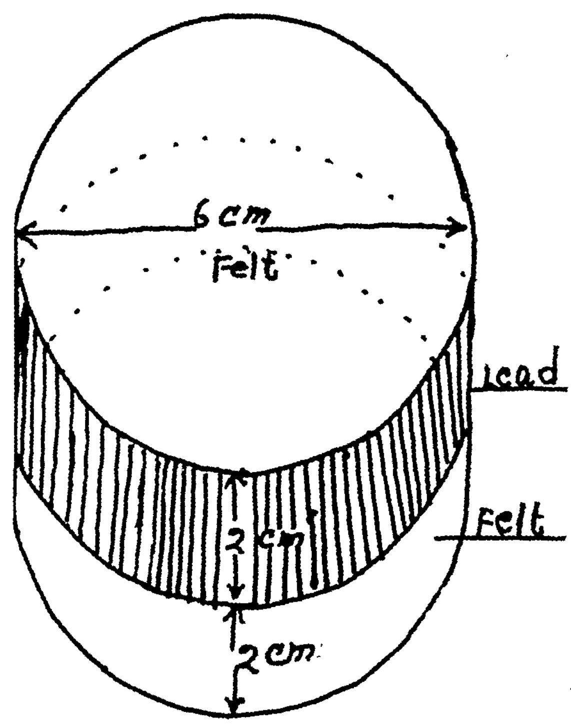

Fig. 5. Shows a circular arrangement with the distribution of the radium capsules around the border under a layer of one-eighth inch of lead, and the upper portion surrounded by one-eighth inch of lead, so as to control some of the stray radiation. This is useful for smaller areas of treatment, not exceeding 6 cm.

[3] One Imc. expresses 0.001 of the intensity produced by 1 gr. radium, filtered through 0.5 mm. platinum only, at a distance of 1 cm., the radium preparation being so small that the source may be considered as a point.

described produces a moderate grade of epidermitis, with desquamation of the epidermis, but usually no vesiculitis or ulceration of the skin. A moderate degree of epithelitis of the mucous membrane is also produced, but it seems to me there is definitely less disturbing effect on the skin, mucous membrane, and normal tissue, in proportion to the effect on the malignant disease, than when treated by roentgen rays alone. With this management, there seems to be less disturbance of the general health, such as nausea, vomiting, prostration, but one does have dryness of the mouth and throat associated with sticky mucus. I have gotten some relief from the sticky mucus by giving the patient a teaspoonful of essence of caroid, taken as often as necessary. I have found aquaphor useful, as recommended by Kaplan, spread upon gauze and applied twice daily over the epidermitis. An alkaline antiseptic gargle and mouth cleanliness is also helpful in the management of the epithelitis of the mucous membrane.

From a statistical standpoint, no one has had as much experience as Coutard, and no one has analyzed his cases so carefully. In spite of his extensive experience, his results have varied from no "five-year recoveries" for the year 1922, to 66 per cent for the year 1932, yet 1921 gave 50 per cent and 1929 only 14 per cent. Therefore, the variable results are not merely a matter of experience or progressive improvement in technic. No one has been more studious or critical of his technic than Coutard. His average results for the years from 1921 to 1932, during which he has treated with roentgen rays and obtained 39 five-year recoveries out of 142 cases so treated, show 27 per cent of five-year recoveries. The fact that Coutard still insists upon the use of low intensity per minute has encouraged me to write this brief report, hoping that someone having a large amount of material may be able to prove its value statistically, which I have not done. I present this, therefore, for what it is worth, drawing no conclusions.

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PNEUMATIZATION OF THE MASTOID[1]

A ROENTGEN STUDY

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THIS communication purposes to trace the growth and development of the mastoid radiographically; to correlate roentgen findings to anatomic and clinical conceptions, and to elaborate on a recently proposed anatomic classification based on pneumatization.

The present classification of mastoids as pneumatic, diploic, or sclerotic is neither sufficiently informative anatomically nor of great assistance otologically. Although several excellent anatomic and histologic studies of the temporal bone and of pneumatization of the mastoid have been made, little has been done to correlate these studies to the actual radiograph of the mastoid, and to correlate the variations of pneumatization, as identified radiographically, to the variations in the clinical manifestations of mastoiditis.

GROWTH

The true mastoid process is evolved from the petromastoid part of the temporal bone, which becomes fused with the squamozygomatic portion of the squamous part and the tympanic part to form the entity known as the mastoid.

The squamozygomatic portion of the squamous part forms the outer wall and part of the tegmen of the attic and antrum. Radiographically, the squamozygomatic portion is visualized more clearly in the first two years of life than is the petromastoid. The latter, termed the "mastoid mass" by Cheatle (1), is a diploic bone; it offers itself to invasion by air cells which emanate and radiate from the area covered by the squamozygomatic bone. This area is the most important landmark on a mastoid film, and is termed the "peri-antral triangle." It encompasses the attic, aditus, antrum, and labyrinth, and corresponds to the base of the petrous pyramid; it covers the spaces which represent the center of activity in initiation and promulgation of pneumatization; it is also the first area to show signs of pathologic change.

The mastoid grows in three dimensions, its outline expanding from above downward, from before backward, and from within outward. Growth, as such, occurs under any and all conditions and is independent of pneumatization, except that with extensive pneumatization, growth is more expansive than with little or no pneumatization, in which case growth is somewhat limited. Growth begins at birth, accelerates between the ages of two and five, and is practically complete at six years, after which there is little demonstrable increase in the size of the mastoid.

PNEUMATIZATION

Concomitantly with growth, air cells develop in the normal mastoid by a process termed "pneumatization." This process is governed by vital and anatomic factors, the influence of which causes each mastoid to attain an individual cell pattern which differs from that of its mate and is sufficiently characteristic for actual identification.

Pneumatization has been the subject of considerable discussion in which many opinions and various theories have been expressed. Cheatle (1), Wittmaack (2), and Albrecht (3) are agreed that cell formation is initiated in intra-uterine life, Wittmaack placing the time as the fifth month. The middle ear and antrum from which cells develop are laid down and remain as one continuous cavity, the lining membrane of which is continuous with that of the Eustachian tube and nasopharynx.

Wittmaack describes the middle ear,

[1] This is one of a series of papers contributed by friends and former pupils of I. Seth Hirsch, M.D.

epitympanic space, and antrum as being filled with embryonic connective tissue which is gradually replaced by epithelial tissue before birth and during the first year of life; in the period between the first and fifth year of life, bone spaces in the mastoid become confluent, retaining their bone columns which extend into the lumens like "bone splinters"; the embryonic bone marrow is absorbed and replaced by subepithelial connective tissue, while the "bone splinters" grow and subdivide, thus generating new spaces. The building of bone spaces by confluency, with secondary invagination of mucosa, Wittmaack terms "eccentric-cell formation"; the subdivision of existing spaces by "bone splinters," he terms "concentric-cell formation."

Regarding the origin of cells that invade the mastoid, Wittmaack describes (*a*) a small number as coming from the epitympanic recess; (*b*) a majority as coming from the antrum, and (*c*) most of the terminal cells and those on the anterior surface of the mastoid as coming from the middle ear. This author states that the mastoid process should be completely pneumatized by the end of the fourth or fifth year, subsequent to which there is slow but unimportant continuation of pneumatization during the whole lifetime.

Albrecht believes that the degree of pneumatization depends on individual predisposition, such as the relation between the energy of the proliferating epithelium and the resistance offered to it by the surrounding tissue.

Cheatle believes that the formation of cells depends on the density of the separating layer of bone between the squama and the mastoid mass.

Proetz (4) thought the antrum and air cells to be a result of a plastic rearrangement of the skull, necessitated by the disproportionate growth of the cranium and associated structures, *i.e.*, cavities left by the separation of two walls of bone. To avoid physical disturbances, the cavities communicate with the external air by way of the nearest air cavity from which they arise, and are, therefore, lined with the membrane of that cavity. Proetz states also that air cells do not cross suture lines.

Eagleton (5), on the other hand, states that the stimulus resulting in pneumatic bone growth during infancy and early childhood is furnished by a rapidly proliferating surface epithelium from the upper respiratory tract. He believes that cell formation in the mastoid is to protect the labyrinth from external violence, and he terms the mastoid a neurocranial protective special-sense bone, which increases in size through the successive formation of additional small air-filled spaces. According to Eagleton, air cells occasionally do cross suture lines.

Koch (6) applies Wittmaack's theory to pneumatization of the nasal sinuses and states that when the mastoid is poorly pneumatized, the sinuses too are poorly pneumatized. This contention is not in agreement with the findings of Turner and Porter (7), who state that "the frontal sinuses, like the cellular mastoid processes, attain no distinctive size which can be said to be peculiar to any type of skull or to any race. The frontal sinuses, like the mastoid-cell area, show marked variations in size in individual skulls in the majority of races. An undeveloped frontal sinus is like an acellular mastoid; diploic bone is present in both. There is no evidence, either in individual skulls or in groups of skulls, that the frontal sinuses and the cellular mastoid spaces attain a similar degree of development."

Relationship between sinus and mastoid pneumatization has never been evident to the writer, who, in examining over 5,000 sets of mastoid and sinus films, has yet to find any significant similarity of pneumatization of either the nasal sinuses or the petrous pyramids and of the mastoid processes.

However, this brief summary of normal pneumatization does not account for the great variability in extent and pattern of mastoid-cell formation, particularly in individuals who have never had ear disease.

According to Cheatle's studies, which were purely anatomic by dissection, the

extent and pathways of pneumatization are determined by anatomic features and bone characteristics.

Wittmaack made anatomic and histologic examinations from which he concluded that the type of mastoid development was predetermined by pathologic changes in the mucosa, which resulted from trauma set up before, during, or after birth. He differentiates mucosal changes into two types: a hyperplastic type, the result of foreign body irritation, such as caused by amniotic fluid, vernix caseosa, and meconium, and an exudative type, which leads to fibrosis as a result of inflammatory reaction to infection of the infant ear. As sequelæ to these pathologic changes in the mucosa, various grades of disturbance of pneumatization obtain, depending on the type of inflammation, the degree of destruction of the mucosa, and the time of its occurrence. Wittmaack believes that the hyperplastic mucosa permits pneumatization to continue, but leads to irregularity of cell arrangement and eventually to sclerosis, whereas the fibrotic mucosa puts an end to pneumatization, without affecting the remaining spongy bone which appears diploic and not sclerotic. He contends that milder grades of fibrosis merely delay the process of pneumatization.

Albrecht calls attention to hemorrhage as a disturbing factor. In his studies of premature and new-born specimens, hemorrhages were observed in many, probably due to birth injury. Damage to the epithelial and connective tissue, such as infiltrative and inflammatory changes, could easily disturb and even inhibit pneumatization.

Nasal blockade in infancy, with resultant diminution of air supply and air pressure in the middle ear, is worthy of consideration as a possible factor in disturbance of pneumatization.

It seems quite significant that most of the specimens examined by investigators are either adult bones or those of the fetus and new-born infant. Because of this discrepancy in age of specimens studied and the absence of radiographic evidence of changes that occur in the living mastoid, it has been difficult for some investigators to accept Wittmaack's theories. Marx (8) questions whether examination of an adult bone, in which pneumatization is defective, entitles Wittmaack to assume as a fact that an infantile otitis was responsible for the defect. Marx feels that it is impossible to separate the hyperplastic and exudative forms of otitis. Wittmaack (9) replies to Marx with further evidence of histopathologic changes in the tympanic mucosa, reaffirming his original classification and asserting that the two forms may occur in mixture. He maintains that the hard, sclerotic mastoid results from hyperplastic infantile otitis and a total arrest of pneumatization at an early stage; he is unable to conceive a symptomless total destruction of epithelial lining with secondary ossification, and supports his view by stating that it has never been shown that a gradual sclerosis of the mastoid develops in the course of chronic suppuration of the middle ear. He does concede, however, that new bone formation is not uncommon in all forms of mastoiditis, whereby some pneumatic cells are obliterated by newly formed bone after necrosis of the epithelial lining.

Mayer (10), too, takes exception to some of Wittmaack's theory because he finds certain types of temporal bones on radiographic examination which do not fit into Wittmaack's scheme. Mayer believes that different qualities of mucosa, reacting differently to inflammation, result in different patterns of pneumatization.

Pneumatization is probably dependent on a combination of factors, mainly, (1) the vigor of the proliferating epithelium and its forerunner, the embryonal connective tissue; (2) freedom from middle ear irritation by foreign bodies and hemorrhage, incidental to the birth process; (3) anatomic predisposition; (4) free communication with the external air, and (5) a healthy mucosa, capable of resisting infection or of recovering from infection without severe damage and degeneration. Moreover, failure of pneumatization (*i.e.*,

inhibition) and arrest or disturbance of pneumatization may be assumed to result from an alteration in one or more of these factors. Many of Wittmaack's contentions are reasonable from a clinical point of view. Frequently one finds that on careful subsequent inquiry for an etiologic factor, a history of infantile otitis is elicited after it had been originally denied. Infantile otitis often remains unnoticed; contagion otitis is often unnoticed and untreated, and ear suppuration early in life is often allowed to exist for unduly long periods without surgical aid. These undoubtedly disturb the process of pneumatization sufficiently to manifest defective development in later life.

With the exception of the classical works of Cheatle and Wittmaack, little reference is made to the period of development between one and six years of age. The importance of this period is emphasized by the writer in his following contentions which are based on radiographic evidence.

(1) Pneumatization of the mastoid is initiated in infancy and completed in early childhood, all within the first six years of life. At the age of six, the full complement of cells is present; thereafter, there is no perceptible increase in number but the cells do become more distinct by virtue of continued calcification of their walls.

(2) Variations of pneumatization resulting from inhibition and arrest of pneumatization, when they occur, are invariably demonstrable as a fixed mastoid pattern by the end of the sixth year of life.

(3) By the end of the sixth year, the growth of the mastoid has attained adult proportions, but at no time does the number of cells determine the size of the mastoid.

(4) Alteration of the fixed mastoid pattern can occur after the sixth year, only as the result of subsequent infection, trauma, or disturbances of bone metabolism.

TABLE I.—MASTOIDS

Group I Normal Development		Group II Defective Development	
Type 1.	The Infant Mastoid (birth to two years)	Type 1.	The Undeveloped Mastoid (after two years)
			(*a*) Cellular
			(*b*) Diploic
			(*c*) Sclerotic
Type 2.	The Transitional Mastoid (two to five years)	Type 2.	The Partially Developed Mastoid (after six years)
			(*a*) Squamal tract
			(*b*) Antral tract
			(*c*) Tympano-tip tract
			(*ab*) Squamal and antral
			(*ac*) Squamal and tip
			(*bc*) Antral and tip
Type 3.	The Fully Developed Mastoid (at and after six years)		

ANATOMIC CLASSIFICATION

From the foregoing review of the theories of the process of pneumatization, it becomes evident that the most informative classification of mastoids would be one that is based on pneumatization. In a previous communication (11), the writer stated that mastoids may be classified according to their growth and development, development being synonymous with pneumatization. Growth is not as important as development, clinically, and whereas all mastoids grow, some mastoids do not develop at all, which others present marked and distinctive variations in development. Therefore, the state of development for age, and its variations, judged radiographically, constitute desirable criteria for grouping and typing all mastoids.

Thus, mastoids are divided into two groups, the first consisting of those which evidence normal development for their age, and the second of those which evidence defection of development, as shown in Table I.

In this classification, the so-called diploic and sclerotic mastoids are not recognized

as entities. The petromastoid bone which gives rise to the mastoid process is diploic and remains so if there is inhibition of pneumatization; with arrest of pneumatization, that part which was not invaded by air cells remains diploic (normal skull bone). Sclerosis, on the other hand, results from a break in the balance between local blood supply and local calcium, most probably of pathologic origin. Thus it may occur anywhere in any except the infant type of mastoid.

THE PERI-ANTRAL TRIANGLE

For judging development whereby mastoids may be grouped and typed, the peri-antral triangle is the landmark of prime importance. It is defined on a radiograph

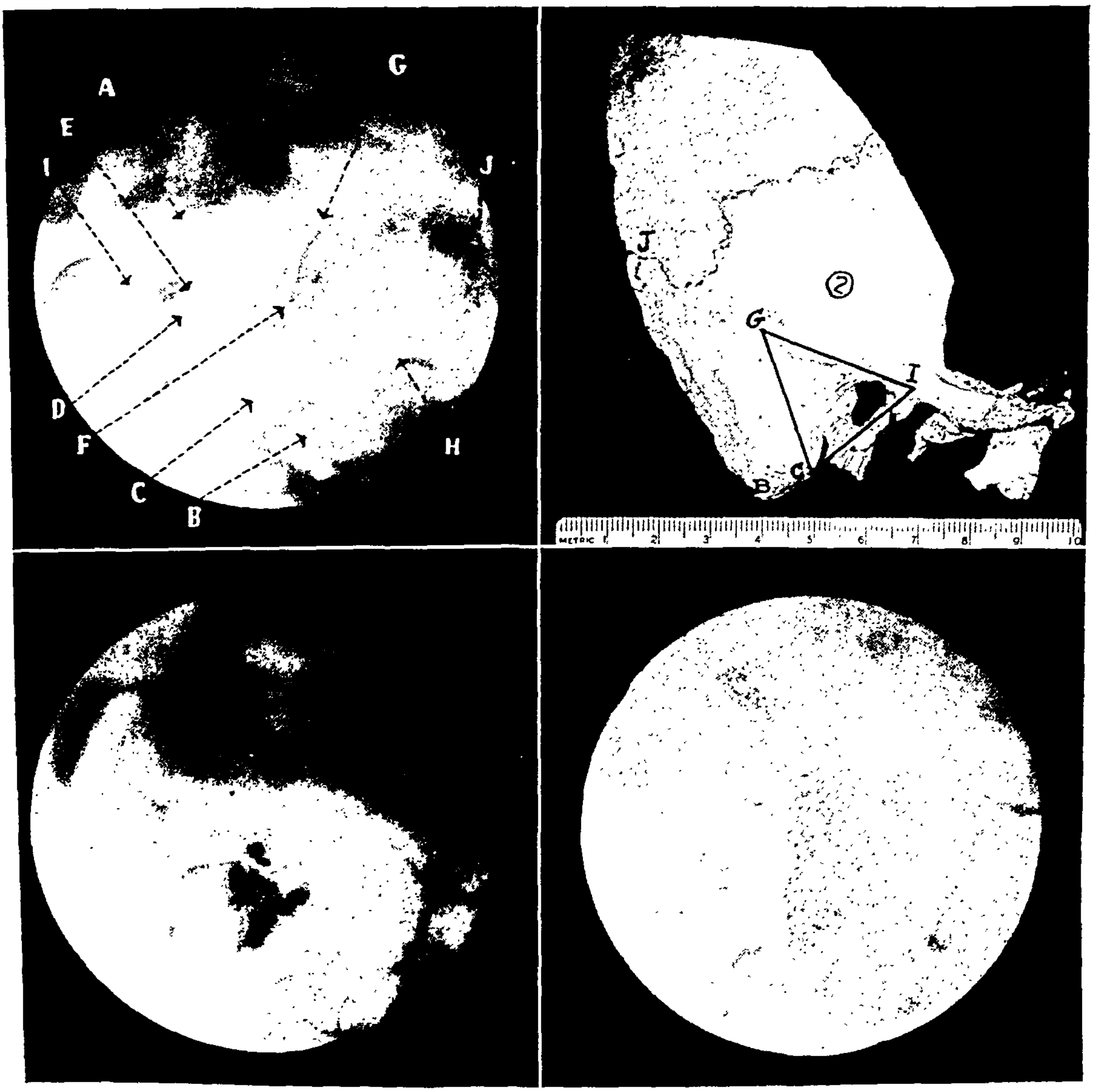


Fig. 1 (*upper left*). The peri-antral triangle (radiograph of an undeveloped mastoid). *A*, arcuate eminence or tegmen line; *B*, center of mastoid tip; *C*, tympano-mastoid fissure (lower angle of triangle); *D*, floor of external meatus; *E*, posterior wall of external meatus; *F*, sinus plate (anterior lip of groove); *G*, parietal notch; *H*, emissary vein at posterior border of mastoid; *I*, post-glenoid process, and *J*, asterion.

Fig. 2 (*upper right*). The peri-antral triangle (external view of the mastoid). *I*, post-glenoid process; *G*, parietal notch; *C*, tympano-mastoid fissure; *B*, center of mastoid tip, and *J*, asterion.

Fig. 3 (*lower left*). The transitional mastoid (age, three years). Note expanding cells pointing in three directions.

Fig. 4 (*lower right*). Transitional mastoid (age, four years).

(Fig. 1) as being almost equilateral, and is bounded by the line of the tegmen above, posteriorly by the groove for the sigmoid sinus, and anteriorly by a line joining the other two. Concisely, the superior line runs from the post-glenoid process backward and almost horizontally to the parietal notch; the posterior line runs from the parietal notch diagonally forward and downward, corresponding to the anterior lip of the groove for the sigmoid sinus. It terminates at the lowermost point of the tympanomastoid suture; the anterior line completes the triangle, running through the anterior wall of the canal. The same lines obtain on the external view of a temporal bone (Fig. 2).

The triangle is roughly the equivalent of Cheatle's "outer antral wall," corresponding to the squamozygomatic portion of the squamous part of the temporal bone. On a radiograph, the triangle encompasses the shadows of the antrum, the peri-antral cells, and the labyrinth, and corresponds in outline to the base of the petrous pyramid. Before the age of two, the triangle may or may not be visualized clearly; it begins to appear sharp between the ages of 15 and 20 months, and is quite distinct at two years. Therefore, development is judged only after two years, at which time, under normal conditions, cells begin to migrate beyond the borders of the triangle; however, when development is inhibited, no cells appear outside the triangle.

The peri-antral triangle is so basic a landmark that it is visualized very clearly on radiographs taken after simple and radical mastoidectomy and even after numerous revision operations on the mastoid.

GROUP I.—NORMAL DEVELOPMENT[2]

Type 1. *The Infant Mastoid.*—This is the normal mastoid of the first two years of life. At birth, it possesses the shadows of the tympanic ring and labyrinth, which structures are already calcified. From six to twelve months of age, there is an increasing definition of the antrum and of a few surrounding small cells, which have very fine lines; these are seen running criss-cross in all directions, between the age of 15 and 18 months. At this time, the tegmen line is already sharp, while the posterior line of the triangle is first becoming sharp. At 24 months of age, the triangle is sufficiently calcified to permit visualization. There may be a number of small white (bone) lines extending upward toward the squama and a number radiating backward across the sinus groove. In some mastoids the squamal lines appear earlier and are more prominent. The bone over (*i.e.,* external to) and posterior to the sinus groove is uniformly smooth in texture, extending to the parietal and occipital suture lines. Occasionally, on light films, the groove for the emissary vein is visible.

Type 2. *The Transitional Mastoid.*—This is the mastoid which is found between the ages of two and five, a period that marks the transition in growth and development from the infant type to the fully developed type.

During this period, there is slow expansion of cells (Fig. 3), migration toward the periphery, and concomitant multiplication of cells and increase in the size of the mastoid process (Fig. 4). The migrating cells are characterized by fine, elongated, thinly calcified lines, which exhibit a directional tendency. They offer poor radiographic contrast as compared with cells of the adult type, because they are calcified to a lesser degree and because the mastoid process is not so deep as the adult type. For the same reasons, interpretation of pathology in this type of mastoid is quite liable to error.

During the third and fourth years of life, the long fine lines of migrating cells are spaced regularly and irregularly, radiating backward, upward, and downward from the antral area as a center. From these lines, short, thin, spike-like projections appear at irregular intervals. They probably are the "splinters" to which Wittmaack refers. The projections gradu-

[2] Radiographic appearance and measurements apply to films made at 30 inches, in the 15 × 15 degree position, without diaphragm.

ally blend to envelop numerous small areas which assume the appearance of small rounded air cells. There are many such small cells within the peri-antral triangle, but, posterior to the triangle, they do not become numerous and distinct until about the fifth year. In many mastoids the spike-like projections do not appear in the peripheral zone, permitting the expanded cells to remain large (Fig. 5).

As pneumatization spreads beyond the borders of the peri-antral triangle, cell formation takes place in three directional groups (Fig. 6) as follows:

(1) *The Squamal Tract.*—Cell lines extend upward from the antral area, perpendicular to the tegmen line which they cross to invade the squama. The more anterior lines may turn forward to invade the zygomatic process (Fig. 7), occasionally to a marked extent; the posterior cells are limited by the parietal notch.

(2) *The Antral Tract.*—Cell lines course backward from the antral area to cover the sinus groove and to travel toward the parietal and occipital sutures. Some lines radiate upward to cover the knee of the sinus, travelling up to and in front of the parietal notch while others course below and past the parietal notch, but they never cross it and never invade the parietal bone. Other lines flow downward to reach the tip, truly resembling a waterfall as they leave the antral area. Non-directional lines represent cells travelling toward the cortex, medio-laterally.

(3) *The Tympano-tip Tract.*—Cell lines, rather hidden, pass downward and slightly backward from the middle ear, in front of and alongside the anterior lip of the sinus groove, to and into the tip. They often turn backward and upward to follow the outline of the tip toward the emissary vein. This tract is mentioned by Cheatle

TABLE II.—MEASUREMENTS OF MASTOID GROWTH AND DEVELOPMENT

Group and Type	Age	A-B	A-C	A-D	D-B	E-F	E-G	E-H	I-J	U-V	W-Y	X-Z
Normal Development												
Group I	at birth	15		13	10			25	45			
Type 1	6–12 mos.	15–20		12	10–12			25	50	20	20	15
Infant Mastoid	18 mos.	18–20	18–20	14	15	10	15	25–30		25	25	20
	2 yrs.	20–25	20	15	16	10	20	25–30	55			
Type 2	$2\frac{1}{2}$ to 3 yrs.	22–25	20–25	15	18–20	10–15	20	25–35		25	30	25
Transitional Mastoids	$3\frac{1}{2}$ to 4 yrs.	25–30	20–30	16	20–25	15	25	25–35		35	35	35
	5 yrs.	30–32	25–30	15–20	22–26	15	25	30–35	60	45	45	35
Type 3	6 yrs.	35–40	25–30	15–20	25–30	15	25	35	60–65	45	45	35
Fully Developed	7–60 yrs.	35–40	25–30	15–20	25–30	15	25	35–40	60–65	40–50	45	35
(Bone Specimens—Adult)		40	30	20	26	15	26	38	55			
Defective Development												
Group II	5 yrs.	30	25	15	20	10	20	35				
Type 1	13 yrs.	30	30	15	20	13	25	35	50–60			
Undeveloped Mastoids	adult	35	30	15	20	12–14	20–25	35–40	50–60			
(Bone Specimens—Adult)		30–32	25	20	20	15	25	28	50			
Type 2 (*a*)	Squamal	35–40	25–30	15	25	15	25	30–40	50–60	40	25	25
Partially Developed (*b*)	Antral	35–40	25–30	15	25	15	20–30	30–40	50–60	30–50	20–35	25–30
Mastoids (*c*)	Tip	30–35	25–30	15	25	15	20–30	30–40	50–60	10–20	10–25	20–35
Age 7–65 yrs.	*a* and *b*	35–40	25–30	15	25–30	15	30–35	30–40	50–60	55	50	45
	a and *c*	35–40	25–30	15	25	15	30–35	30–40	50–60	50	40	35
	b and *c*	35	25–30	15	25	15	30–35	30–40	50–60	40	30	35

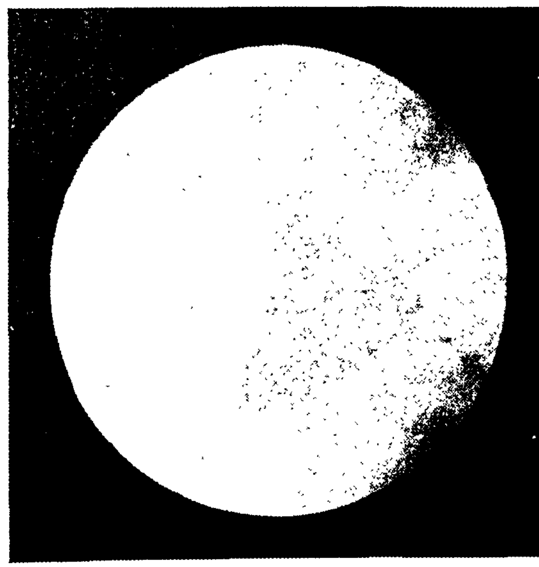
Measurements are average and are expressed in millimeters. They apply to films made at 30 inches in the 15 and 15 degree position, without diaphragm. Radiographic measurements of the living mastoid and of bone specimens coincide. The antrum at birth measures 10 × 10 mm. Cells in squama extend to from 10 to 20 mm. above the tegmen line. Over-all cell mass averages in adult 40 × 45 mm., and rarely exceeds 50 × 55 mm. In one mastoid at age five, the over-all cell mass measured 55 mm. from above downward and 65 mm. from before backward, including zygomatic cells. *A-B*, Arcuate eminence (highest point on tegmen line) to center of tip; *A-C*, Arcuate eminence to lower angle of peri-antral triangle; *A-D*, Arcuate eminence to floor of meatus; *D-B*, Floor of canal to center of tip; *E-F*, Posterior canal wall to anterior lip of sinus groove; *E-G*, Posterior canal wall to posterior angle of triangle; *E-H*, Posterior canal wall to posterior border of mastoid at emissary vein; *I-J*, Post-glenoid process to asterion; *U-V*, Uppermost cell to lowermost cell; *W-Y*, Most anterior cell to most posterior cell, and *X-Z*, Posterior canal wall to most posterior cell.

as coming into relation to the canal for the facial nerve; it is described more specifically by Wittmaack, and has been demonstrated more recently by Almour (12). When cell formation is proceeding evenly throughout the mastoid, the tympano-tip tract is not perceptible as such, but when there is failure of the antral tract to invade the tip and the tip tract is developed, it then becomes apparent. This tract is responsible for the formation of a broad tip in the fully developed mastoid. In its absence, the tip is narrow or pointed.

Vigorous pneumatization is evidenced by the simultaneous development of cells in all three tracts at a uniform rate, all groups merging and blending to form a heterogeneous mass of cells. No one group of cells or pathway of pneumatization is outstanding; the course of the sigmoid sinus gradually becomes obscured; there is an orderly convexity of the periphery which is broken only by the indentation produced by the parietal notch. The superior and posterior lines of the peri-antral triangle are almost hidden by cells. The mastoid is about to attain a state of full development.

Type 3. *The Fully Developed Mastoid.*—This mastoid no longer shows signs of transition. It possesses a full complement of cells, which extends close to, if not up to, the posterior border, into the squama, into the tip, and sometimes into the zygoma. The cell walls are calcified, the cells are superimposed except at the extreme periphery, and the mastoid process is deep. Therefore there is good radiographic contrast. The course of the sigmoid sinus and the superior and posterior lines of the peri-antral triangle are barely distinguishable. The emissary vein may or may not be visible.

The cells of the *squamal tract* are usually of medium size, round or oblong, and placed in shallow formation; cell lines run upward, meeting to form an inverted *U*. In the zygoma, the cell lines run forward and slightly upward, the open end of the *U* facing the antral area. The cells of the *antral tract* are multishaped, small or large and somewhat elongated peripherally. The open end of the *U* faces the antrum, and represents the opening by which the cell was "blown"; in the antral tract, the *U*-shaped closure of the cell is toward the posterior border, except in cases in which cells are running toward the external cortex of the mastoid, in which case there is no *U* formation, the cells appearing cir-



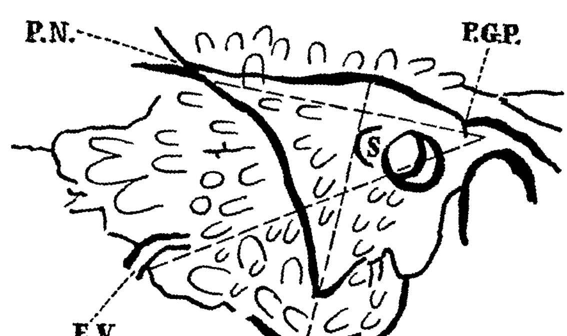


Fig. 5 (*above*). Transitional mastoid (age, five and one-half years).

Fig. 6 (*below*). Schema of pathways of pneumatization. The squamal group appears above a line drawn between the parietal notch (*P.N.*) and the post-glenoid process (*P.G.P.*). The antral group appears between two lines extending backward from the *P.G.P.* as a center, the upper running to the parietal notch, the lower to the emissary vein (*E.V.*). Antral cells appear posterior to a line drawn from the arcuate eminence to the center of the tip, which line runs through the shadow of the external semicircular canal (*S*). The tympano-tip tract group appears below the middle ear on the anterior surface of the mastoid, anterior to the last mentioned line, until the cells reach the tip, whence they curve backward and upward.

cular. The *tympano-tip tract* cells are large, as a rule, the lines pointing downward, thence backward and upward from the center of the tip. The *U*-shaped closure is found facing the antrum in some tip cells, thus differentiating them from those of the antral tract.

The fully developed mastoid may be found as early as at the age of five and at any time thereafter. Very rarely does its appearance change after the sixth year.

GROUP II.—DEFECTIVE DEVELOPMENT

Type 1. *The Undeveloped Mastoid.*—Any mastoid which fails to evidence air cells beyond the borders of the peri-antral triangle after two years is undeveloped. Such a mastoid shows evidence of growth but not of development. It resembles the infant mastoid in outline, but is larger in size. It is often referred to as an "infantile mastoid," a term that is confusing because it places the normal mastoid of infancy in

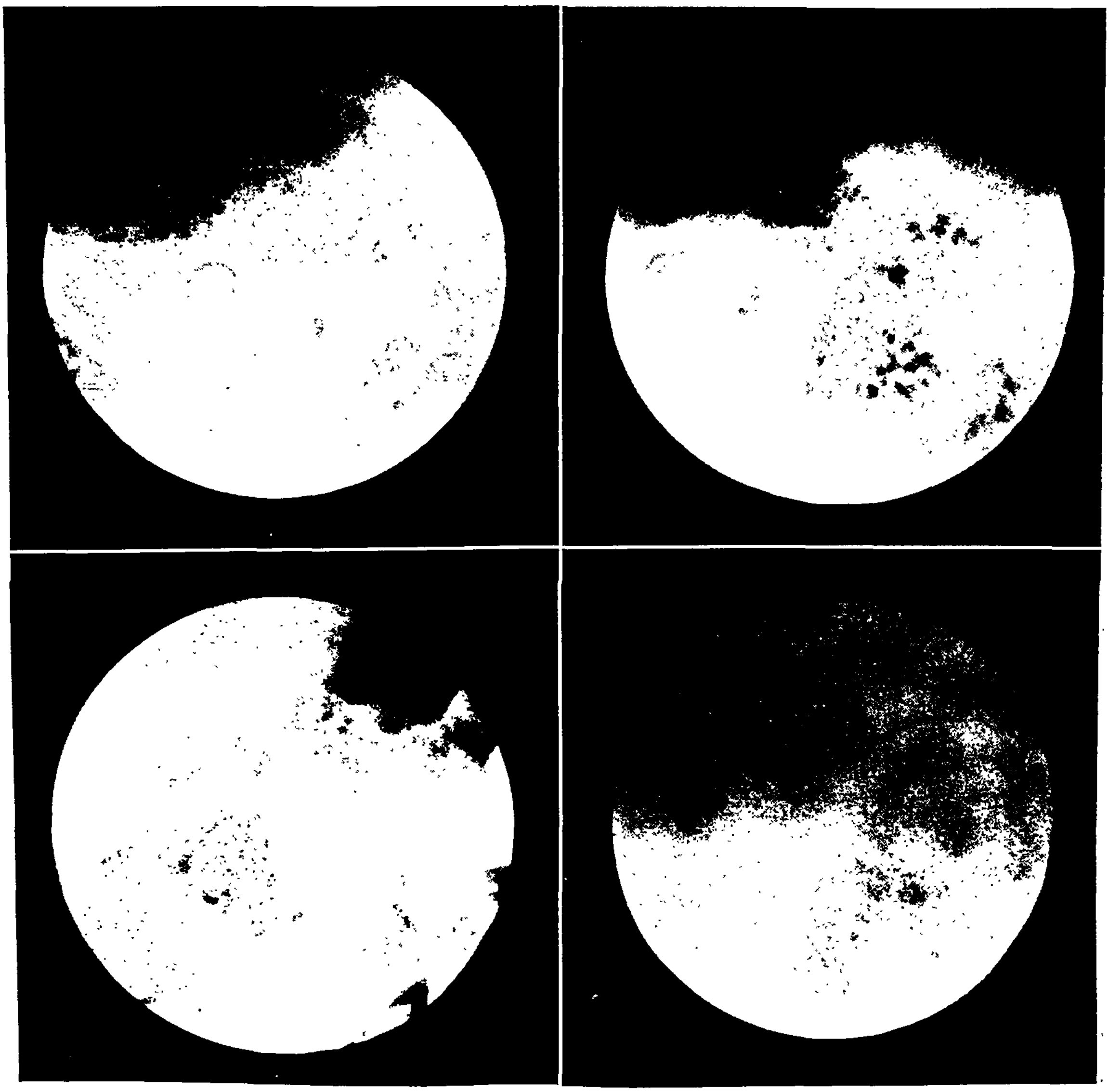


Fig. 7 (*upper left*). Extensive pneumatization of the squama and zygoma.
Fig. 8-*A* (*upper right*). Fully developed mastoid.
Fig. 8-*B* (*lower left*). Partially developed mastoid. Arrested pneumatization produces a break in the peripheral convexity, giving a clear impression, in this film, of the three groups of cells.
Fig. 9 (*lower right*). Partially developed mastoid, squamal group (age, three and one-half years). The antral and tip groups are definitely arrested.

the same category with an older mastoid which has failed to pneumatize and is, therefore, not normal.

The undeveloped mastoid is characterized by a prominent peri-antral triangle and a sharply defined sinus groove. It is subclassified according to the content and texture of its peri-antral triangle, as being: (*a*) cellular—the triangle is filled more or less with cells; (*b*) diploic—the triangle has few or no cells and manifests a texture of diploic bone; semicircular canals may be identified, and (*c*) sclerotic—the triangle is a dense mass of bone, so opaque that identification of any structure within the triangle is difficult, if not impossible.

Failure of development is found bilaterally more often than unilaterally. Otitis of infancy is predominantly a bilateral lesion. Associating these two facts, one may conclude that infection or other disturbance in the middle ear, in the first two years of life, is the cause of non-development. Speculatively, one may assume that damage to the mucosa, produced during intra-uterine life or at birth, results in the diploic type of undeveloped mastoid, whereas damage to the mucosa during the first year of life results in the cellular type of undeveloped mastoid. The sclerotic undeveloped mastoid has never been identified by the writer before the age of five years and seems always associated with recurrent or chronic suppuration of the ear.

Sclerosis in mastoids under ten years of age is an infrequent radiographic finding, anatomic findings to the contrary notwithstanding. The writer has exhibited a comparison of four pairs of mastoids of patients, each 13 years of age. Two of the patients had been under his care since early infancy for their original bilateral otitic suppuration and for recurrent otitic infections; the other two had never had suppurative otitis, but were examined radiographically, one because of recent trauma, the other because of defective hearing. The four pairs of mastoids are undeveloped and have a remarkably similar radiographic appearance. The authentic record of suppuration in two of these patients coincides with the conception of otitis of infancy as the cause of non-development of the mastoids.

It is reasonable to assume that non-development of the mastoids in the other two patients resulted from fetal or infantile otitis, despite the history of no recognized suppuration or recurrent infection. In the

TABLE III.—MEASUREMENTS OF PERI-ANTRAL TRIANGLE

(Averaged and Expressed in Millimeters)

Type of Mastoid	Age	I-G	G-C	C-I
Normal Development	1 yr.	25	25	20
" "	2 yrs.	30	25	25
" "	3 yrs.	30	30	30
" "	4 yrs.	35	35	30
" "	5 yrs.	35–40	35	35
Undeveloped	6 yrs.	30	25	25
"	9 yrs.	30	30	25
"	12 yrs.	35	35	30
"	adult	35	30–35	30
Partial Development (*a*) Squamal	4 yrs.	30	25	25
"	adult	30	30	30
(*b*) Antral	"	35	25	25
(*c*) Tip	"	35	35	35
(*ab*) Squamal and antral	"	35	30	30
(*ac*) Squamal and tip	"	40	30	35
(*bc*) Antral and tip	"	30	30	30

I-G, Post-glenoid process to parietal notch; *G-C*, Parietal notch to lower angle of triangle, and *C-I*, Lower angle to post-glenoid process.

traumatic case, both mastoids are alike, cellular—undeveloped; hearing is normal. In the other non-suppurative case, there is a history of measles and scarlet fever; the drums are dull; hearing is impaired in both ears. Both mastoids show a marked tendency to sclerosis of the triangle; no cells are visible. In both cases of recurrent infection, the right ear had been infected more often than the left and both right mastoids manifested a greater tendency toward sclerosis of the triangle.

Radiographic examination of adult mastoids, with histories of recurrent suppurative otitis or chronic otitis in childhood, usually reveals a sclerosis of ivory density in the triangle, with or without a sclerosis of the mastoid tip and along the posterior border of the mastoid. It is the writer's opinion that the evolution of sclerosis in the mastoid is a very gradual, time-consuming process; that sclerosis is a graded deposit of calcium salts resulting from a diminution in local blood supply and an excess of local calcium, following inflammatory irritation. Therefore, sclerosis is considered the result of a defense reaction to past disease and not evidence of a recent lesion. The so-called "sclerotic mastoid" is not considered a type of mastoid nor an entity, for sclerosis may occur in individual cells, in discrete areas, and throughout the mastoid, often superimposed on diploic bone.

Type 2. *The Partially Developed Mastoid.*—The mastoid process may develop rapidly or slowly, may contain many or few cells, and may attain a relatively large or small size. It develops into different shapes, becoming tall or short, broad or narrow, deep or shallow. The characteristic individuality of each mastoid results from a combination of developmental features, in which pneumatization plays an important part.

With vigorous pneumatization, there is usually full development of the mastoid (Fig. 8-*A*). When pneumatization fails to occur, there remains an undeveloped mastoid. After pneumatization has already begun and has extended beyond the borders of the peri-antral triangle, it is still subject to arrest. It may be halted generally at any stage of its progress (Fig. 8-*B*). On the other hand, it is possible for one or two of the three directional groups of cells to be arrested, while the other one or two continue to develop, together or individually, at the same or at different rates of speed and to the same or different extents.

Arrest of pneumatization occurs between the ages of two and five years, and results in a partially developed mastoid, the cell pattern of which is fixed for life at the age of six years. It is identified by a break in the convexity of the peripheral outline of the cell pattern, or by an extension of cells solely in one direction beyond the triangle. Thus, cells may be found—

(*a*) Solely in the squamal tract, outside and above the triangle (Fig. 9).

(*b*) Solely in the antral tract, running backward below the tegmen and above the tip, across the sinus groove (Fig. 10).

(*c*) Solely in the tip, emerging from the lower angle of the triangle and occupying part or the whole of the tip (Fig. 11).

(*ab*) Invading the squama and coursing over the sinus groove, even reaching the posterior border of the mastoid, but the tip is narrow or pointed and contains a few antral tract cells, else it is rounded and diploic. This picture probably results from an infection of the middle ear which alters the mucosa that proliferates into the tympano-tip tract without affecting the antral mucosa (Fig. 12-*A*). Another possibility is that the middle ear in question does not possess the anatomic pathway which gives passage to the tympano-tip tract of cells (Fig. 12-*B*).

(*ac*) Invading the squama and the tip; the knee of the sinus groove is exposed to view, no cells covering it. This void over the sinus knee is occasionally misinterpreted as necrosis in that area (Fig. 11).

(*bc*) Filling the tip and rounding out the whole mastoid up to the line of the tegmen. The squama is void of cells. This mastoid closely resembles the normal, fully developed one.

ROENTGEN, CLINICAL, AND SURGICAL CORRELATIONS TO THE PATTERNS OF PNEUMATIZATION

A. Roentgen Signs in Acute Infection.—The infant mastoid will evidence loss of aeration in the antrum. At no time does the radiographic appearance of the infant mastoid speak for or against surgical intervention.

The transitional mastoid will evidence loss of aeration and decalcification. The latter must not be confused with destruction of bone. Loss of definition of the fine lines of migrating cells and increasing opacity of the cell mass indicate necrosis.

The fully developed mastoid will manifest loss of aeration, decalcification, and increased visibility of deeper structures, namely, the sinus groove and the semicircular canals. Destruction is evidenced by loss of continuity of cell lines and coalescence of cells with increasing opacity of the

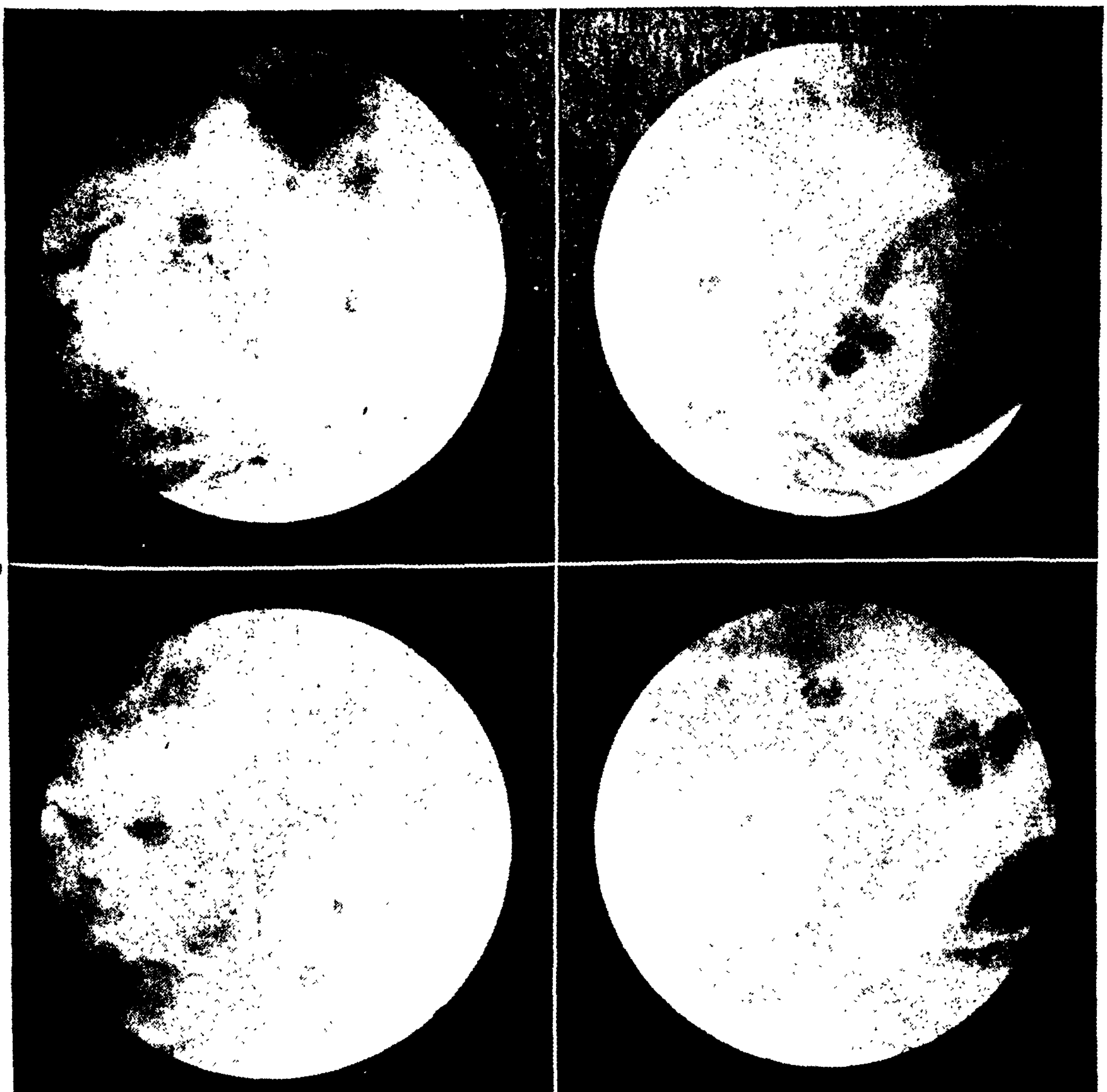


Fig. 10 (*upper left*). Partially developed mastoid, antral group (adult).
Fig. 11 (*upper right*). Partially developed mastoid, tympano-tip tract (adult).
Fig. 12-*A* (*lower left*). Partially developed mastoid, tip tract completely arrested, squamal group well developed, antral group arrested in part (age, seven and one-half years). History of suppurative otitis media.
Fig. 12-*B* (*lower right*). Partially developed mastoid; the squamal and antral groups are well developed. The tip group is missing, as evidenced by a diploic tip (adult).

cell mass. This picture is diagnostic of a surgical mastoid.

The cellular undeveloped mastoid will lose aeration in the triangle. The diploic and sclerotic undeveloped mastoids will show no change at all.

The partially developed mastoid will evidence changes in proportion to the degree of its cellularity. The squamal tract, being shallow, will lose cell outlines sooner than it will evidence changes in aeration, when necrosis takes place.

The antral tract will act like the fully developed mastoid. The tip tract will lose aeration and cell outlines, the tip area becoming opaque.

The petrous pyramids, on base films, nearly always appear alike and symmetrical, though the pneumatization of the two mastoids differs widely. Recurrent mastoid infection and several revision operations for such infection do not, as a rule, produce any perceptible change in the appearance of the pyramids.

B. Symptoms in Acute Mastoiditis.—Headache is a symptom common to all types of mastoids, except the infant.

Temperature elevation may or may not be present in any type of mastoid.

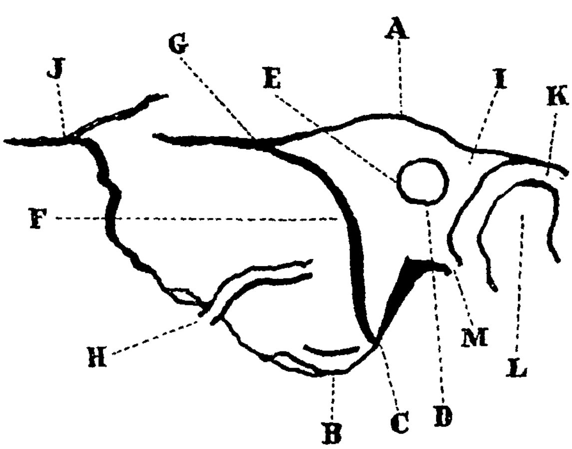


Fig. 13. Diagram of mastoid radiograph, showing points from which measurements in Tables II and III are made, and localizing other landmarks. *A*, arcuate eminence; *B*, center of tip; *C*, lower angle of peri-antral triangle; *D*, floor of canal (meatus); *E*, posterior wall of canal (meatus); *F*, sinus plate (anterior lip of groove); *G*, parietal notch; *H*, emissary vein at posterior border of mastoid; *I*, post-glenoid process; *J*, asterion; *K*, glenoid cavity or fossa; *L*, condyle of mandible, and *M*, styloid process.

Mastoid pain, subjectively, may be present in any type; but objectively, elicited as tenderness, it is greatest in fully developed and transitional mastoids. It is elicited at the posterior border when the structure of the mastoid permits filtration of the toxin and/or micro-organism from the mastoid into the highly sensitive periosteum. Under these conditions, it is not found in undeveloped mastoids and it is not a frequent finding in partially developed mastoids, in which cell formation was arrested close to the peri-antral triangle.

Early and persistent tip tenderness is a sign of a well-developed tympano-tip tract.

Sagging of the canal is dependent on the presence of cells in the region of the posterior and superior canal walls, and results from periosteal infiltration secondary to infection of those cells: conversely, no cells, no sagging.

Discharge is purely a middle ear affair. The quantity of discharge is not proportionate to the cellularity of the mastoid nor to the severity of the infection. In fact, there may be no discharge in the presence of extensive destruction of the mastoid.

C. Surgical Correlations.—Infant mastoiditis is antritis plus osteïtis of the "mastoid mass" of diploic bone. The area of necrosis therefore extends beyond the limited pneumatic area seen on the film.

Suppuration in the squamozygomatic cells (zygomatic mastoiditis) may perforate above and anterior to Macewen's triangle; suppuration in the antral tract may perforate in Macewen's triangle or just below and behind it; suppuration in the tip tract leads to empyema of the tip, Bezold perforation, and suboccipital and digastric fossa abscess. This tract is also responsible for the occasional involvement of the facial nerve.

Epidural abscess is often secondary to suppuration in the squamal tract. Perisinus abscess is secondary to suppuration in the antral tract. Sinus thrombosis will occur in any type of mastoid. A spreading infection of the middle ear finds no harbor in an undeveloped mastoid, and, therefore,

leads to intracranial infection, which term includes labyrinthitis, petrositis, and sinus phlebitis and thrombosis, sigmoid and bulbar. This statement does not imply that such complications do not and cannot occur in other types of mastoids, but it does imply that the classical symptoms of mastoiditis do not occur in an undeveloped mastoid. Early and wide exposure of the pathways of extension of infection is necessary in such cases as soon as signs of intracranial involvement are noted.

The appearance of the mastoid cortex on surgical exposure gives no clue to the state or pattern of pneumatization. These can be determined only by x-ray examination.

D. Regarding Hearing.—The degree of pneumatization, failure and arrest of pneumatization, are not indicative of the functional capabilities of the ear as a sense organ. There may be hearing defects in the presence of normal pneumatization, and there may be normal hearing in the presence of defective pneumatization. However, the most common finding in cases of defective hearing is defective pneumatization with sclerosis.

SUMMARY

Roentgen study of a large number of films of the mastoid reveals evidence of distinct types of mastoids. These types have distinct variations of pneumatization for a given age. The variations fall into separate classes, according to the pathways of development. These pathways, which are demonstrable radiographically, correspond closely to the pathways of pneumatization found on histologic and anatomic examination. The types of mastoids and the variations in pneumatization are sufficiently distinct radiographically to serve as a basis for a definite classification. The practical application of this roentgen-anatomic classification is demonstrated by the correlation of variations in pneumatization to variations in symptoms and in surgical indication.

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CONCRETE AS A PROTECTIVE MATERIAL AGAINST HIGH VOLTAGE X-RAYS[1,2]

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ABSTRACT

A description is given of relative x-ray transmission measurements on a group of especially prepared concrete specimens and commercial building blocks selected to sample the concrete mixes and cover the range of concrete densities in common use. It was found that the lead equivalent of any concrete was an increasing function of its mass per unit area and independent of the nature of the mix. Relations between lead equivalence, density, mass, and thickness are given, from which the thickness of concrete necessary for adequate protection can be calculated for any voltage in the voltage interval 200 to 400 kv.

I.—INTRODUCTION

WITHIN the past few years the highest excitation potentials commonly used in x-ray therapy have been raised considerably above the 200-kv. limit of 15 years ago; 400-kv. equipment is now commercially available, and there are numerous x-ray generators of various types operating at potentials between 400 and 1,000 kv. There has been a corresponding extension in the application of x-rays to the inspection of metals, and in the use of x-radiation as a scientific tool in the physical laboratory. With this trend, the need for adequate protection of personnel against very penetrating radiation has become more urgent than ever.

Lead has been the most commonly used protective material; both in metallic form as sheet lead and lead shot and in combination with other materials, as in lead-rubber and x-ray protective glass. For the most penetrating x-radiation available a few years ago, no other protective material compared at all favorably with lead except barium, and the usefulness of the latter was limited by practical difficulties in making a homogeneous barrier. For this reason, the Advisory Committee on X-ray and Radium Protection has made all recommendations for x-ray protection (1) in terms of lead and has recommended that the effectiveness of all other materials be measured by their lead equivalents. In Table I are given the recommended lead barriers for direct x-radiation excited by potentials up to 600 kv.—the present voltage limit of the recommendations. The recommendations of the committee are given in columns 1 and 2 of Table I. Column 3 has been added to show the approximate weight per square foot of lead barrier recommended in column 2. The weight of the required barrier is seen to increase so rapidly with increasing excitation potential that above 200 kv. the cost of lead for such a barrier becomes very high and the problem of supporting the required lead mass becomes serious.

TABLE I.—MASS OF LEAD BARRIER FOR ADEQUATE PROTECTION

Potential	Recommended Minimum Equivalent Lead Thickness	Weight of Barrier[1]
1	2	3
kv.	mm.	lb./ft.(1)
75	1.0	2.4
100	1.5	3.5
150	2.5	5.9
175	3.0	7.1
200	4.0	9.5
225	5.0	14
300	9.0	21
400	15.0	35
500	22.0	52
600	34.0	80

[1]Approximate.

One possible solution is to make the protective barrier of a material which is self-supporting. Concrete suggests itself

[1] This is one of a series of papers contributed by friends and former pupils of I. Seth Hirsch, M.D.

[2] Preliminary report presented at the Fifth International Congress of Radiology, in Chicago, September, 1937.

at once. In any case, however, for radiation of a given quality, the mass of an adequate concrete barrier will always be greater than that of a corresponding lead barrier; but since the concrete is self-supporting and relatively inexpensive, this increase in weight is not particularly objectionable except in the case of installations in existing buildings unable to withstand the additional loading.

Such data (2) as have been published on the lead equivalence of concrete are old and are confined to x-ray excitation potentials not exceeding 200 kv. It is the purpose of the present paper to give the results of measurements on a series of concrete samples and commercial building blocks for x-ray potentials ranging from 200 to 400 kv.

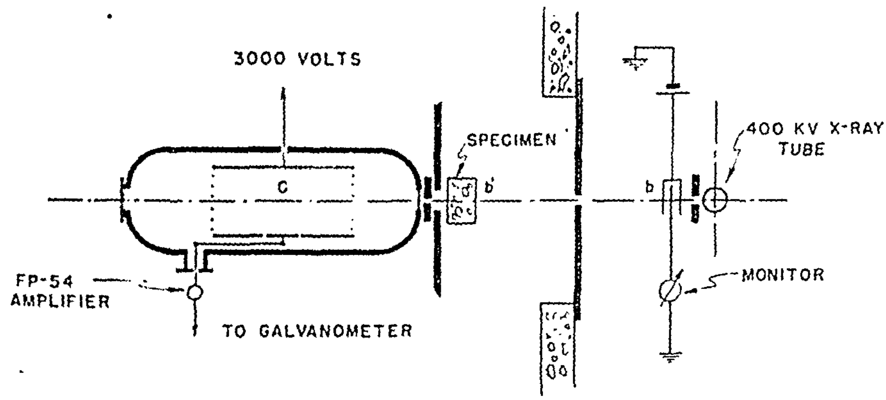

Fig. 1. Diagram of apparatus used in determining the lead equivalent of concrete.

II.—METHOD

The lead equivalent of each concrete sample was obtained by direct comparison with sheet lead, 99.9 per cent pure, meeting Federal specifications for grade *A* lead. The method used is essentially that previously described for determining the lead equivalence of x-ray glass (3). The experimental arrangement is shown in Figure 1; for complete constructional details of the x-ray tube, ionization chamber, and current-measuring system, the original paper describing this apparatus should be consulted (4).

As is shown in Figure 1, the beam of radiation, *bb'*, emerges from the tube at an angle of 90 degrees to the tube axis, and after passing through the concrete test cylinder shown, enters the ionization chamber, *c*. The cross-section of the beam is limited by the four diaphragms shown. The resulting ionization current, after amplification, is measured by direct deflection of a high sensitivity galvanometer in the output of the amplifier. When measuring radiation through heavy protective barriers the residual ionization current due to scattering, radio-active contamination, and cosmic radiation, is a considerable fraction of the total current measured. For such measurements requiring the highest sensitivity, a rate-of-drift method is used in order to get the benefit of a time average for this background radiation; this average remains fairly constant and affects alike the measurements of the standard filters and test specimens, so that, as a rule, no zero correction in the ionization readings is necessary.

III.—DESCRIPTION OF CONCRETE

The concrete specimens, on which tests were made, were selected so as to cover adequately the types of mixes and range of densities most commonly used. These specimens fall into two classes: (*a*) the first consists of a group of especially prepared

TABLE II.—PREPARED CONCRETE SPECIMENS

Specimen	Proportions (cement to sand to gravel)	Approximate Dimensions		Density of Specimens at 24 Hours		C/W[a] Ratio	Consistency, Expressed as Approximate Slump
		Height	Diameter				
Gravel Concrete							
		Inches	Inches	lb./ft.(2)	g./cm.(2)		Inches
G1	1:2.2:3.8	$4^1/_4$	6.0	148	2.3_7	1.60	6
G2	1:2.2:3.8	$6^1/_8$	6.0	146	2.3_4	1.60	6
G3	1:2.2:3.8	$8^1/_2$	8.0	147	2.36	1.60	6
G4	1:2.2:3.8	$4^1/_4$	6.0	152	2.47	1.75	3
G5	1:2.2:3.8	$6^1/_8$	6.0	147	2.36	1.75	3
G6	1:2.2:3.8	$8^1/_4$	8.0	150	2.40	1.75	3
G7	1:2.2:3.8	$4^5/_{16}$	6.0	150	2.40	1.90	1
G8	1:2.2:3.8	$6^1/_2$	6.0	150	2.40	1.90	1
G9	1:2.2:3.8	$8^1/_{16}$	8.0	148	2.37	1.90	1
Limestone Concrete							
L1	1:3.6:2.4	$4^1/_8$	6.0	144	2.31	1.75	3
L2	1:3.6:2.4	$6^3/_8$	6.0	147	2.36	1.75	3
L3	1:3.6:2.4	$8^1/_{16}$	8.0	144	2.31	1.75	3
N	([b])	$4^1/_{16}$	6.0	132	2.1_2	4.17	([c])
NN	([b])	$4^1/_{16}$	6.0	132	2.1_2	4.17	([c])

[a]Cement-water ratio. [b]Neat cement. [c]Normal consistency.

test specimens;[3] (*b*) the second consists of a group of solid building blocks which were obtained on the market. Tables II and III give data on all specimens.

1. *Prepared Specimens.*—Three types of specimens were prepared. Specimens *N* and *NN* were made of neat cement of normal consistency (24 per cent of water). Specimens *G* were nominal 1:2:4 mixes, the exact cement-sand-gravel proportions being 1:2.2:3.8, respectively, by weight. Potomac River sand (quartz), fineness modulus 3.1, was used as fine aggregate. Potomac River gravel (quartz), size No. 4 to $1^1/_2$ inches, was used as coarse aggregate in mix *G*, and Potomac River sand and West Virginia limestone in mix *L*. In mix *L* the sand–coarse-aggregate ratio was adjusted to give maximum density for the mix with the size limestone (No. 4 to $^3/_8$ in.) that was available. The proportions of mix *L* were 1:3.6:2.4.

The specimens were cylinders six or eight inches in diameter and approximately four, six, or eight inches in thickness: the thickness in all cases was not more than the nominal diameter. They were kept in molds for 24 hours, then stored in a moist room for three weeks, after which they were permitted to dry slowly in laboratory air until tested. The gravel concrete was made in three wetnesses. The wettest specimen had as much water as should be used in ordinary construction; the driest was of a consistency that could be used for very special work, in which the extra cost of spading, rodding, and tamping the concrete into the form would be justified by the increase in desirable properties which could be obtained by this rather dry concrete.

2. *Building Blocks.*—In addition to the prepared samples, three different building blocks were tested. These are listed in Table IV. These blocks were part of a purchase of several hundred made from a manufacturer and contractor in the vicinity of Washington, for use in the construction of protective barriers for the 400-

[3] We are indebted to John Tucker, Jr., of the Cement Section of the National Bureau of Standards, who selected the test samples and under whose supervision they were prepared.

TABLE III.—SOLID BUILDING BLOCKS

Specimen	Dimensions	Density
	Inches	g./cm.(2)
B4	3¾ × 7½ × 11¾	2.0_2
B6	5½ × 6 × 9	2.0_2
B8	7½ × 8 × 13	2.1_0

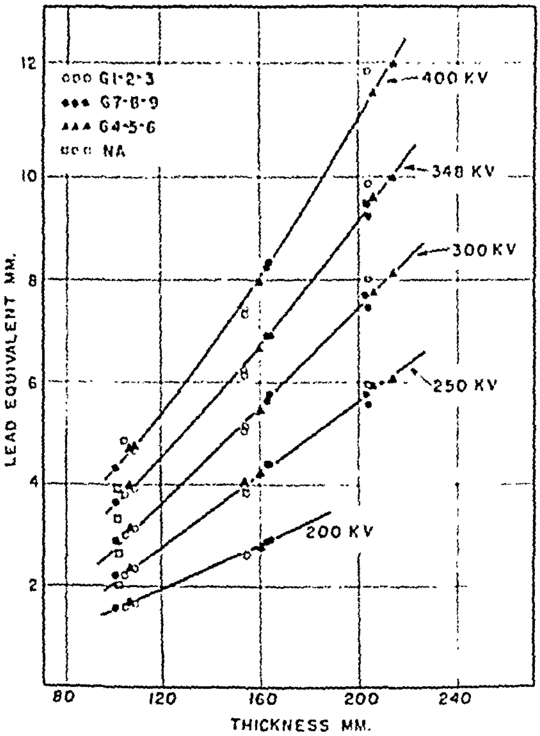

Fig. 2.

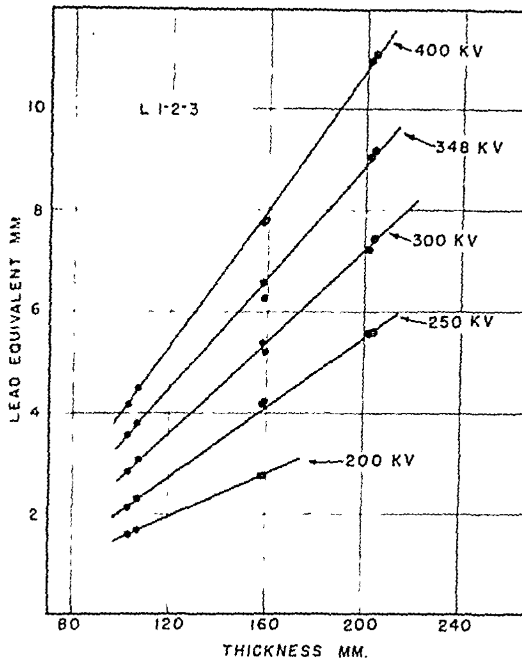

Fig. 3.

Fig. 2. Variation of lead equivalent of a concrete barrier with thickness. (See Table IV for description of specimens.)

Fig. 3. Variation of lead equivalent of a limestone concrete barrier with thickness. (See Table IV for description of specimens.)

kv. x-ray generator of the National Bureau of Standards. Block *B4* was a solid block of rectangular cross-section; blocks *B6* and *B8* had the horizontal cross-section of the usual three-web building block but were solid, that is, the two cylindrical cores ordinarily used in making three-web blocks were omitted. The nature of the mix was not known, except that in accordance with the usual commercial practice the mix was made sufficiently dry to permit prompt removal of the blocks from the machine molds, the ideal mixture for blocks being that which will barely retain its shape when the forms are removed immediately after the concrete has been deposited and pressed into shape. This is a great deal drier than the mixtures ordinarily used in poured concrete.

IV.—RESULTS

1. *Variation of Lead Equivalent with X-ray Voltage and Thickness of Concrete.*—The lead equivalent of each sample was determined at each of the following excitation potentials: 200, 250, 300, 348, and

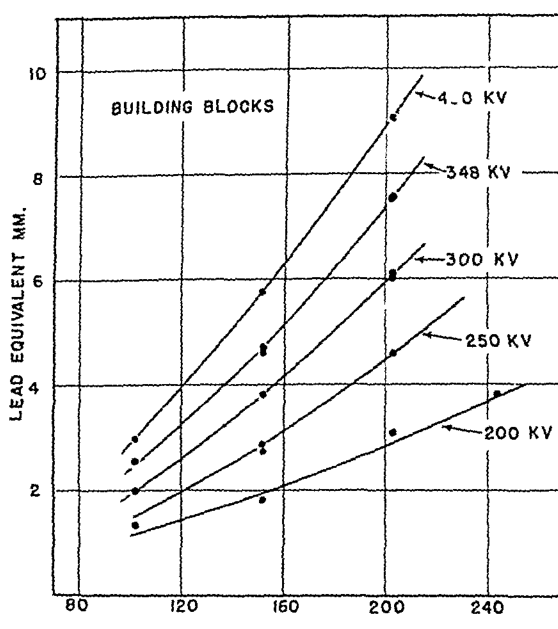

Fig. 4. Lead equivalent of concrete building blocks plotted against thickness of blocks. (See Table V for description of specimens.)

TABLE IV.—LEAD EQUIVALENT OF CONCRETE

Sample	Thickness	Diameter	Density	Lead Equivalent at—					Mass per Unit Cross-section
				200 kv.	250 kv.	300 kv.	348 kv.	400 kv.	
	cm.	cm.	g./cm.(1)	mm.	mm.	mm.	mm.	mm.	g./cm.(1)
G1A	10.5	15.3	2.37	1.60	2.26	3.01	3.82	4.88	24.9
G1B	10.9	15.3	2.37	1.66	2.33	3.13	3.91	4.64	25.8
G2A	15.4	15.3	2.34	2.60	3.86	5.09	6.18	7.42 7.32	36.0
G2B	15.4	15.3	2.34	2.58	3.96	5.12	6.23	7.45 7.42	36.0
G3	20.4	20.4	2.36	....	5.97	8.03	9.86	11.00	48.1
G4A	10.9	15.3	2.47	1.70	2.40	3.17	3.97	4.73	26.9
G4B	10.7	15.3	2.47	1.70	2.37	3.12	3.98	4.66 4.68	26.4
G5A	15.4	15.3	2.36	2.63	4.01	5.13	6.30	7.40	36.3
G5B	16.0	15.3	2.36	2.77	4.20	5.44	6.66	7.97 7.92	37.8
G6A	20.6	20.3	2.40	....	5.80	7.73	9.59	11.59	49.4
G6B	21.4	20.3	2.40	....	6.06	8.11	9.97	12.16	51.4
G7A	10.8	15.3	2.40	1.70	2.34	3.12	3.98	4.68	25.9
G7B	10.1	15.3	2.40	1.58	2.21	2.90	3.64	4.31	24.2
G8A	16.3	15.3	2.40	2.90	4.42	5.64	6.93	8.22	39.1
G8B	16.4	15.3	2.40	2.93	4.40	5.77	6.92	8.32	39.4
G9A	20.4	20.3	2.37	....	5.59	7.47	9.23	11.29	48.3
G9B	20.3	20.3	2.37	....	5.76	7.70	9.48	11.58	48.1
G10A	10.1	....	....	1.49	2.00	2.70	3.47	4.02	....
G10B	10.6	....	....	1.58	2.16	2.95	3.69	4.33	....
G11A	15.1	....	....	2.36	3.74 3.73	4.89	5.97	7.02 7.06	....
G11B	15.5	....	....	2.55	3.92	5.10	6.23	7.42 7.33	....
L1A	10.7	....	2.31	1.67	2.30	3.07	3.80 3.78	4.49	24.7
L1B	10.3	....	2.31	1.57	2.13	2.85	3.50 3.55	4.19	23.8
L2A	15.9	....	2.36	2.77	4.22	5.40	6.56	7.80	37.5
L2B	15.8	....	2.36	2.78	4.19	5.39	6.57	7.76	37.3
L3A	20.4	....	2.31	....	5.61	7.45	9.19	11.10	47.1
L3B	20.2	....	2.31	....	5.57	7.33	9.02	10.92	46.7
NA	10.2	....	2.12	1.52	2.03	2.69	3.34	3.92	21.6
NNA	10.3	....	2.12	1.52	2.00	2.68	3.34	3.90	21.8
X	20.7	....	....	....	5.72	7.67	9.44	11.52	....
B4	....	....	....	1.33	1.48	1.99	2.53	2.99 2.98	19.5
B6	....	....	....	1.80	2.74 2.76 2.89	3.80	4.65 4.60 4.70	5.76 .... 5.73	29.7
B8	....	....	....	....	4.58	6.03 6.07	7.52 7.50	9.04	41.6

400 kv. No beam filter was used, the only filter being 2 mm. of copper and 10 mm. of aluminum inherent in the x-ray tube.

The results of these tests are tabulated in Table IV and are plotted in Figures 2, 3, and 4. It is apparent from these data that the lead equivalent of a sample of given density depends not only on its thickness but also on the x-ray excitation potential as well, and above 200 kv. increases with both.[4]

2. *Variation of Protection Coefficient with Density.*—Figure 5 is a typical plot of the protection coefficients as a function of density for samples of approximately equal thickness.[5] The samples of Figure 5 were cylinders approximately four inches thick; similar plots were made for samples six and eight inches thick. The lines were drawn

[4] The complete curve showing the lead equivalent of concrete as a function of the excitation potential has a minimum at approximately 200 kv. and a low maximum at about 100 kv. However, the portion of the curve below 200 kv. is of little practical value.

[5] "Protection coefficient" has been defined as follows by the American Advisory Committee on X-ray and Radium Protection: "The protection coefficient of a material is the ratio of the thickness of lead to the thickness of the material which absorbs a given x-ray beam to the same extent."

so as to pass through the origin of the coordinate system as they would do if the protection coefficient varied linearly with differences in their protective coefficients can be explained simply in terms of their densities.

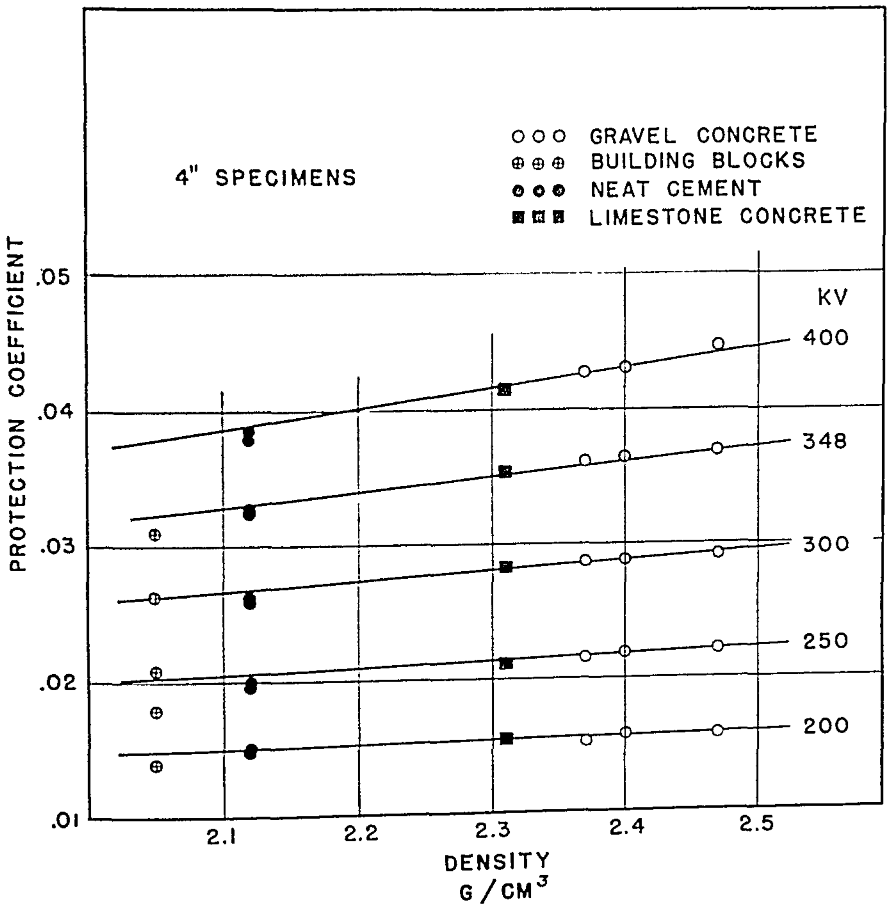

Fig. 5. Variation of protection coefficient of four-inch concrete test cylinders with density of specimens.

the density of the concrete. It appears that within the experimental error of the measurements the points do fall on the lines so drawn, and we may, therefore, conclude that within this quality range the protection coefficient of concrete is directly proportional to the density of the concrete. It follows that in this range the components of the concrete mix do not directly affect the protective quality of the material aside from their effect on the concrete density. In Figure 5, four different concrete mixes are included: Two specimens are neat cements, one is a limestone concrete, three are gravel concretes, and two are building blocks of unknown composition; yet the observed

3. *Thickness of Concrete Required for Protection.*—Since there are no striking differences in the lead equivalents of samples of equal density but varying composition, there is no particular advantage in making tests on many different samples; and, therefore, all subsequent measurements extending these tests to lead equivalents greater than the recommended lead thicknesses were confined to two groups of samples designated as *G* (density 2.36) and *B* (building blocks, density 2.0 to 2.1_0). These data are summarized in Table V and are plotted in Figures 6 and 7. In these figures, the intersection of the dotted curve with the full-line curves gives

the thickness of this concrete required to give the degree of protection recommended by the Advisory Committee on X-ray and Radium Protection. For concrete of some slightly different density, the required thickness can be obtained if its density is

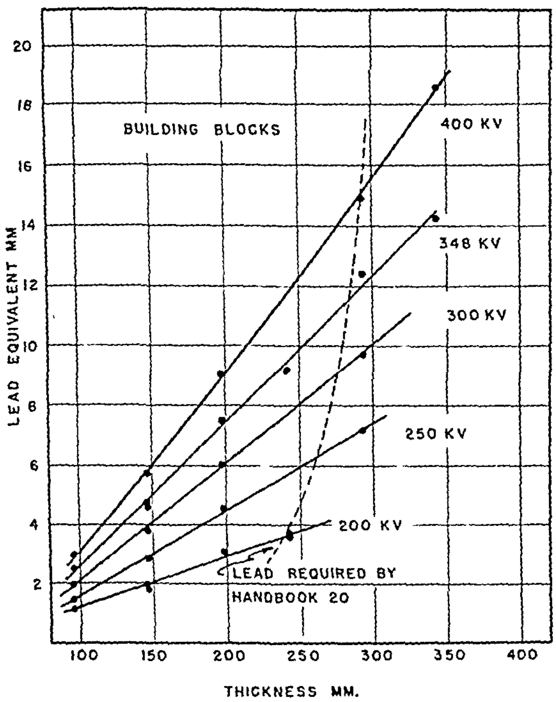

Fig. 6.

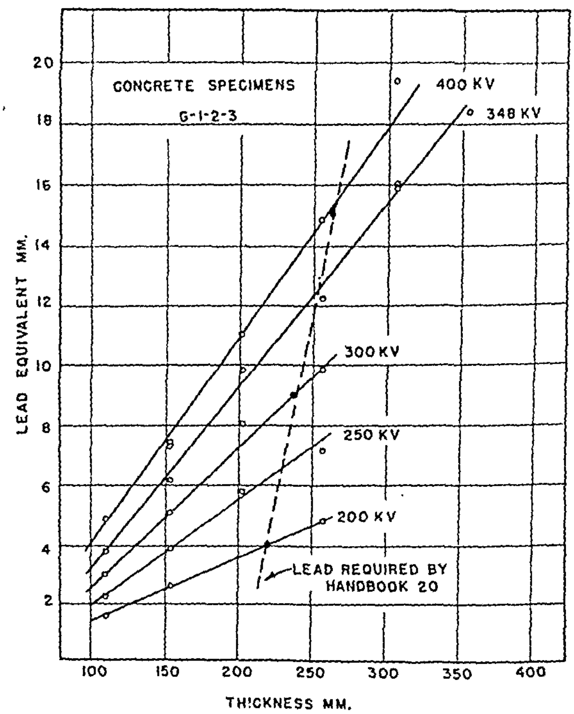

Fig. 7.

Fig. 6. Curves for obtaining required thickness of barrier made of building blocks of average density 2.05 g./cm. (1).
Fig. 7. Curves for obtaining required thickness of concrete barrier of average density 2.35 g./cm. (1).

TABLE V.—LEAD EQUIVALENT OF CONCRETE

Sample	Average Density	Thickness	Lead Equivalent					Mass per Unit Cross-section
			200 kv.	250 kv.	300 kv.	348 kv.	400 kv.	
	g./cm. (1)	cm.	mm.	mm.	mm.	mm.	mm.	g./cm. (1)
G1A	2.37	10.5	1.59 1.60	2.26	3.01	3.82	4.88	24.9
G2A	2.34	15.4	2.60	3.86	5.09	6.18	7.42 7.32	36.0
G3	2.36	20.4	....	5.97	8.03	9.86	12.00	48.1
G1A + *G2A*	2.35	25.9	4.79	7.14	9.81	12.2 12.2	14.8	61.1
G1A + *G3*	2.36	30.9	....	....	....	15.9 15.8	19.3	72.9
G2A + *G3*	2.35	35.8	....	....	....	18.3	....	84.1
B4	2.0_3	9.6	1.15 1.33	1.48	1.99	2.53	2.99 2.98	19.5
B6	2.0_2	14.7	1.89 1.80	2.74 2.76 2.89	3.80	4.65 4.60 4.70	5.76 5.73	29.7
B8	2.1_0	19.8	3.0_7	4.58	6.03 6.07	7.52 7.50	9.04	41.6
B4 + *B6*	2.0_2	24.3	3.58 3.90 3.67	....	....	9.14	10.5	49.1
B4 + *B8*	2.0_7	29.4	....	7.1_8	9.6_8	.....	14.2 14.9	61.2
B6 + *B8*	2.0_6	34.5	....	....	.....	14.2	18.5	71.7
Required for adequate protection	....	....	4.0	....	9.0	.....	15.0	....

known, since for samples of approximately equal thickness the lead equivalent varies linearly with density. However, in using Figures 6 and 7 to compare concretes of widely different densities, it should be remembered that the protection coefficient of a sample depends also on the sample thickness; therefore, to determine the required thickness of any concrete it should be compared with a concrete of greater rather than with one of lesser density; by making this determination in this way a thickness somewhat greater than that required will be obtained and the error resulting will be on the safe side.

4. *Variation of Lead Equivalent of Concrete with Mass per Unit Area.*—All absorption data on concrete given above for various mixes, densities, and thicknesses are conveniently summarized in Figure 8, in which the lead equivalent of a concrete barrier is plotted against the mass of the barrier per unit cross-sectional area. For a given voltage, all samples in this graph fall on a single curve, no matter what the composition, density, or thickness of the individual samples may be. For this reason, the thickness of a concrete barrier required for adequate protection can be most conveniently obtained from Figure 8 by use of the relation $L = M/D$, where L is the thickness of concrete barrier; M is the mass of barrier per unit area required to give the desired degree of protection—obtained from Figure 8, and D is the density of the concrete used.

As has already been noted, the curves in Figures 6 and 7 must be used with caution when the density of a given concrete is widely different from those used as standards in these two graphs. It is clear that no such precautions are necessary in making the same determination by means of Figure 8 and for this reason its use is recommended.

5. *Concrete-lead Mass Ratio.*—In Figure 8 the dotted curve is for metallic lead; this is included for the purpose of comparing the mass of a concrete wall with that of a lead barrier providing equivalent protection. Table VI contains a summary of such a comparison for 200-, 300-, and 400-kv. radiation.

In column 5 of Table VI there are given the ratios of the mass of a concrete barrier to the mass of its lead equivalent. The ratio is high at the lower excitation potentials; at 200 kv. an adequate concrete barrier has about twelve times the mass of

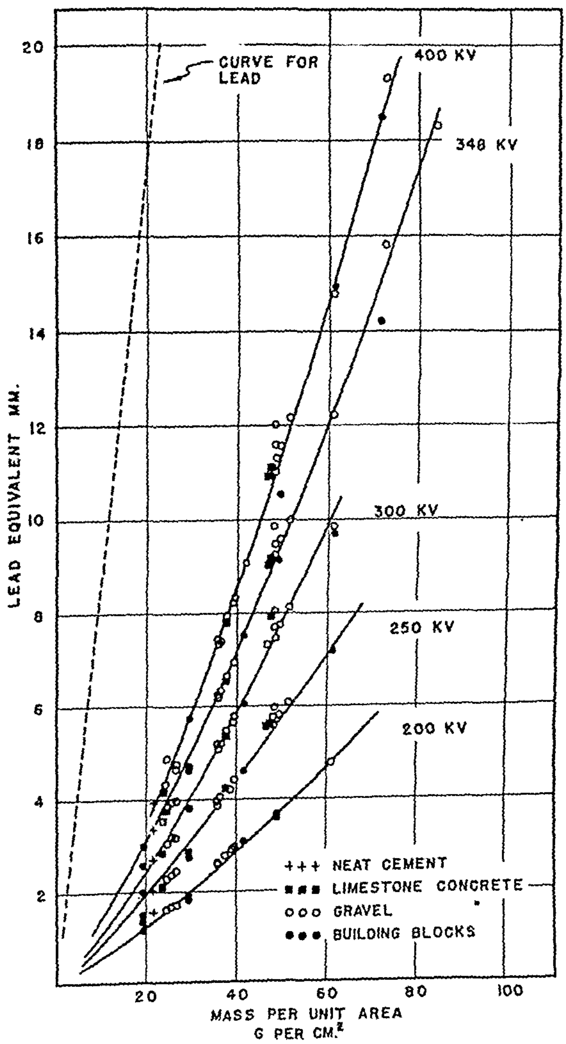

Fig. 8. Lead equivalent of any concrete barrier as a function of the mass of the barrier per unit cross-sectional area.

TABLE VI.—CONCRETE-LEAD MASS RATIO

Potential	Recommended Lead Equivalent	Mass per Unit Area: Lead	Mass per Unit Area: Concrete	Mass of Concrete / Mass of Lead
1	2	3	4	5
kv.	mm.	g./cm.	g./cm.	
200	4.0	4.5	53	11.8
300	9.0	10.2	57	5.6
400	15.0	17.0	60	3.5

its lead equivalent, while at 400 kv. the concrete barrier has only three and a half times the mass of an equivalent lead shield.

V.—CONCLUSION

Since the protection coefficient of concrete increases rapidly with increasing excitation potential, the thickness of the concrete barrier which will provide adequate protection at, say, 400 kv., is not very much greater than that required to give the same degree of protection at a much lower voltage. So, from Figure 6, we see that for the building blocks tested, a barrier about 30 cm. (11.8 in.) is adequate at 400 kv., while at 200 kv. the thickness required is about 22 cm. (8.7 in.). Similarly, from Figure 7, the thickness of concrete required at 400 kv. is about 26.5 cm., while the required thickness at 200 kv. is 22 cm.

In both cases the additional thickness required in going from 200 to 400 kv. is small and a barrier providing adequate protection at a given excitation potential will also be adequate at a lower voltage.

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THE VALUE OF RADIOGRAPHY OF THE GALL BLADDER IN THE UPRIGHT POSITION[1]

By RAMSAY SPILLMAN, M.D., *New York City*

THREE years ago, Dr. Alice Ettinger, of Boston,[2] called attention to a phenomenon which, in a bibliography listed by her, had been described before only by Åkerlund, Eliasz, and Bernstein. This communication put me on guard to use the upright position in radiographing the gall bladder, in addition to the recumbent, with the result that in one instance, thus far, an incontrovertible diagnosis of small gallstones was made in a case in which the films made prone showed a normal gall-bladder shadow and no trace of stones.

The principle is extremely simple, and the only reason for reporting this case is to add a note of emphasis as to the value of the procedure. It depends on the following elementary principle: in the upright patient, the gall-bladder contents of highest specific gravity, whether gallstones or bile, gravitate to the fundus of the viscus. In certain cases there is a collection of minute gallstones, comparable in size to canary bird sand, of lower specific gravity than the bile in the most dependent part of the gall bladder, and of higher specific gravity than that in the uppermost part of the gall bladder. In the upright position, this collection forms a radiolucent layer somewhere between the upper and lower end of the gall bladder. In the prone position, it is entirely lost in the shadow of the dye.

In the case here reported, a young woman with textbook history of gallstone colic, the diagnosis would have been entirely missed on the prone films alone.

[1] This is one of a series of papers contributed by friends and former pupils of I. Seth Hirsch, M.D.

[2] Am. Jour. Roentgenol. and Rad. Ther., 35, 656-661, May, 1936.

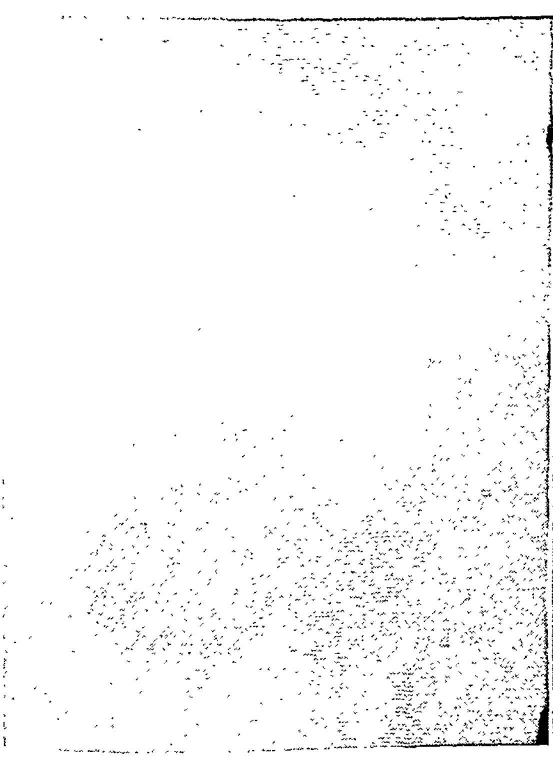

Fig. 1.

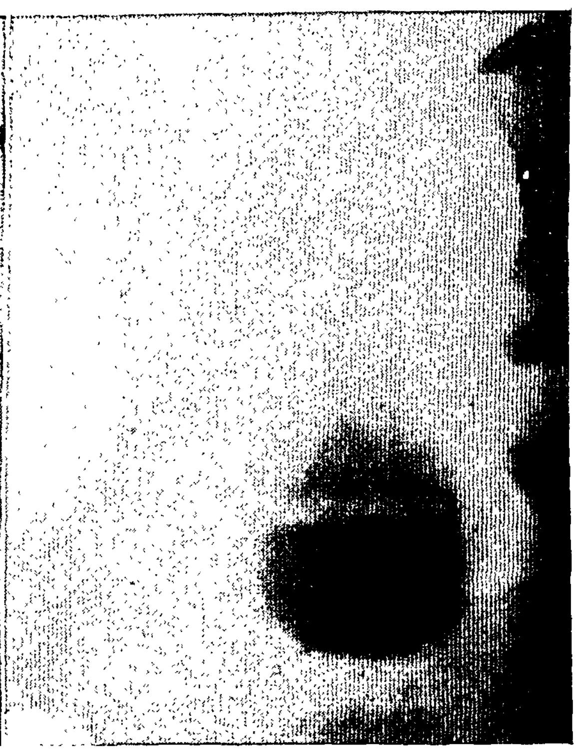

Fig. 2.

On films made in the standing position with the Lysholm grid on the fluoroscope, the clear layer remained horizontal when the patient bent far over to either the right or the left, proving its analogy to a fluid level. The film from which the darker of the two prints was made (Fig. 2) shows clearly a foamy structure of the clear layer, in which individual granules can be clearly discerned.

SUPPURATION IN THE MASTOID AND PETROUS PORTIONS OF THE TEMPORAL BONE: ROENTGEN FINDINGS[1]

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THE temporal bone is composed of four parts: the mastoid process, the petrous pyramid, the squamous, and tympanic portions. The mastoid process and the petrous pyramid are the portions of particular interest because of the prevalence of suppurations within these parts of the temporal bone.

A roentgen study of the temporal bone should include an examination of the mastoid processes and the petrous pyramids. The Law position, or a modification of it, is usually employed for the mastoid processes, and a film of the base of the skull or some other position, for the petrous pyramids. The examination may include other and additional positions, depending upon the type and location of the lesion which is under investigation. Individual preferences enter here. Other positions commonly employed are: Obliques for the mastoid tip, modifications of the Law position, Stenvers, Schüller, Mayer, Granger, MacMillan, and others. When complications to otitic infections are under investigation, it is desirable and often necessary to utilize several of the above-named positions, in order to arrive at a diagnosis.

At birth, the temporal bone is not pneumatized. The mastoid antrum is the only cell present. Pneumatization of the mastoid portion of the temporal bone is a normal process. According to Wittmaack, this follows the invagination of the epithelial lining of the middle ear into the diploic bone of the mastoid process, and the replacement of the latter by the subsequent development of pneumatic cells. Associated with this, there is a proliferation of the embryonal myxomatous connective tissue.

The process of pneumatization in the petrous pyramid is identical with that in the mastoid. It starts either from the inner antral wall, the epitympanic space, or from the peritubal region, and goes forward to the petrous tip. Anything which interferes with the normal process of pneumatization will result in an undeveloped mastoid, or cause a faulty type of pneumatization, with the result that throughout life there will be either a diploic or an incompletely pneumatized mastoid process. This also holds true for the petrosa.

Pneumatization varies considerably, and does not respect boundaries or suture lines. When pneumatization is extensive it may extend into the zygoma, squamosa, occipital bone adjacent to the mastoid, and also into the basilar process of the occipital bone. Pneumatization in the temporal bones is usually symmetrical. Asymmetrical pneumatization does occur, but infrequently.

The mastoid process is usually pneumatized between the ages of three and five. Before the age of three, little or no pneumatization may be present.

Roentgenograms of the temporal bone reveal the following anatomical landmarks:

(A) Mastoid Process.
- (1) Size of mastoid.
  - (*a*) Small or large.
  - (*b*) Cellular development.
    Extensions—zygoma, squamosa, occipital bone, etc.
- (2) Character of structure.
  - (*a*) Small cells.
  - (*b*) Large cells.
  - (*c*) Mixed small and large cells.
  - (*d*) Undeveloped.
    Diploic bone.

[1] This is one of a series of papers contributed by friends and former pupils of I. Seth Hirsch, M.D.

(e) Sclerotic bone.
(f) Combinations of any of the above.
(3) Internal and external auditory meatuses.
(4) Region of the mastoid antrum.
(5) Posterior canal wall.
(6) Tegmen tympani and mastoidei.
(7) Lateral sinus, knee and sigmoid sinus.
(8) Sigmoid sinus wall—ridge on posterior surface of pyramid.
(9) Mastoid tip.
(10) Emissary vein.
(11) Semicircular canals.
(12) Eustachian tube (osseous portion in sclerotic mastoid).

(B) Petrous Pyramid.
(1) Pneumatization.
(2) Character of structure.
(a) Small cells.
(b) Large cells.
(c) Diploic bone.
(d) Mixed small and large cells.
(e) Mixed diploic and pneumatic cells.
(f) Sclerotic bone.
(3) Apical-carotid portion.
(a) Tip.
(b) Middle lacerated foramen.
(c) Superior border—middle fossa.
(d) Carotid canal.
(e) Superior petrosal sinus.
(f) Inferior petrosal sinus.
(g) Jugular fossa.
(h) Area for Gasserian ganglion.
(i) Internal auditory meatus.
(j) Subarcuate fossa.
(4) Labyrinthine portion.
(a) Arcuate eminence.
(b) Superior semicircular canal.
(c) Horizontal and posterior semicircular canals.
(d) Cochlea.
(e) Superior surface.
(5) Post-labyrinthine portion.
(a) Mastoid process.
(b) Lateral sinus.
(c) Sigmoid sinus.
(d) Styloid process.
(e) External auditory canal.

(C) Base of Skull.
(1) Petrosæ (and adjacent structures).
(a) Pneumatization.
(b) Character of structure.
(c) Apical-carotid portion.
(d) Labyrinthine portion.
(e) Post-labyrinthine portion—mastoid.
(f) Middle lacerated foramen.
(g) Superior petrosal sinus.
(h) Inferior petrosal sinus.
(i) Jugular fossa or posterior lacerated foramen.
(j) Lateral and sigmoid sinus.
(k) Foramen magnum.
(l) Basilar process of occipital bone.
(m) Region of Eustachian tube.
(n) Foramen ovale.
(o) Foramen spinosum.
(p) Foramen rotundum.

PATHOLOGICAL MASTOID

(A) *Non-pneumatic.*—Pneumatization is the normal process. If the epithelium lining the mastoid antrum is the site of a pathological process in early infancy, subsequent pneumatization of the mastoid and petrous portions of the temporal bone will not occur following recovery. An otitis media, either catarrhal or infectious, during infancy, prevents pneumatization or arrests further development when pneumatization has already started. This holds true for the petrous pyramids as well as the mastoid processes. A non-pneumatic mastoid in an adult is indicative that an otitis media existed in early infancy. An incompletely pneumatized mastoid is informative of an otitis media in infancy before pneumatization was complete. A mastoid which is non-pneumatized or incompletely pneumatized usually yields a history of an intermittent, a persistent, or a protracted otorrhea. A destructive inflammatory lesion in a non-

pneumatic mastoid is the equivalent of an osteomyelitis. This is an infrequent occurrence. Low-grade otitic infections in non-pneumatic mastoids usually lead to a productive osteitis, a sclerosis of the mastoid process. *A cholesteatoma is a destructive* lesion which develops slowly and occurs only in a non-pneumatic mastoid, due to inclusion of desquamated epithelium through a perforation in the tympanic membrane. As the cholesteatomatous mass becomes larger it destroys its bony surroundings Because of the slow-growing nature of this lesion, there is time for the development of a productive osteitis which appears as a layer of compact bone around the area of destruction. This lesion can attain considerable size. Large cholesteatomas are seldom seen to-day. A cholesteatoma may develop following surgery on a pneumatic mastoid. The epithelium inclusions are from the inverted skin margins of the wound.

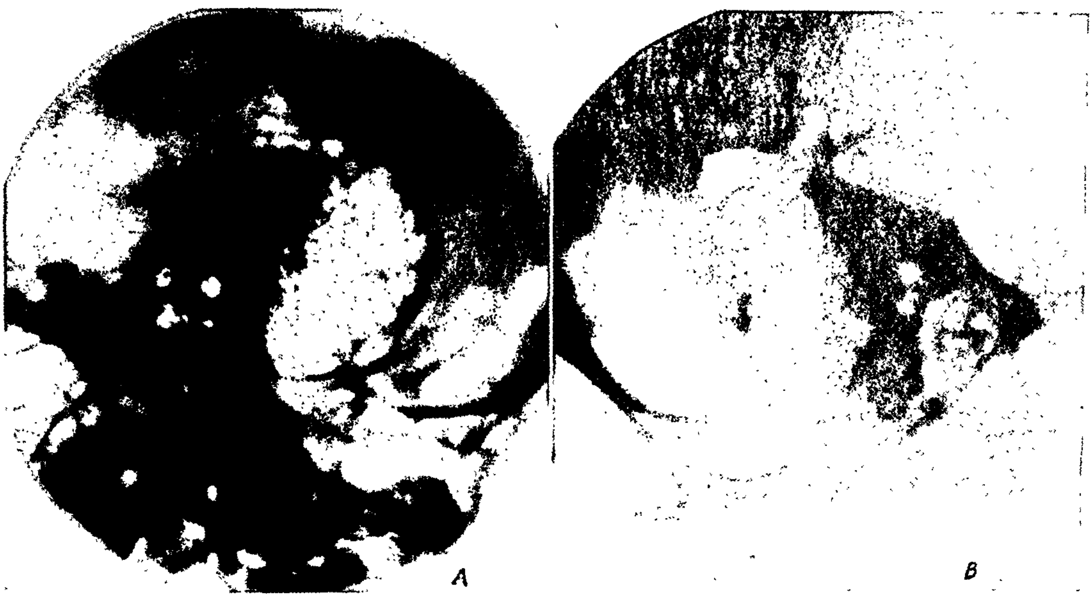

Fig. 1-*A*. Normal, well developed mastoid, composed of small and large cells, with cellular development extending into the squamous and zygomatic areas. Normal aeration.
Fig. 1-*B*. Slight diminution in aeration. Marked diminution in aeration of the antral area. The cell walls are thickened. Loss of definition in the supra- and post-sinal regions. Acute purulent otitis media.

(*B*) *Pneumatic Mastoid.*—The normal mastoid process reveals air spaces with numerous cell walls. The cell walls or trabeculæ appear sharp and dense because of the marked contrast with the air in the cells. *The density of the mastoid structure* is about the same as that of blood. For this reason the ridge on the posterior surface of the petrous pyramid, referred to as the sinus wall, is not always visualized. *The sinus may* be situated anteriorly (*i.e.*, close to the posterior canal wall), posteriorly, or in a median position. Its location in relation to the posterior canal wall is of importance to the surgeon in affording him a guide as to its position within the mastoid. The sinuses which were well forward on a roentgen film were found at operation to be superficial as well. In the undeveloped type of mastoid the sinus is usually forward. The mastoid emissary vein is usually situated midway between the tip of the mastoid and the knee of the sinus. The location of this vein is of importance to the surgeon, enabling him to avoid accidental injury and unnecessary bleeding during operation.

Pathological processes are recognized because they reduce the air content in the cells, and also produce changes in the cell walls.

Acute Otitis Media.—As the name indicates, the infection is limited to the middle

ear. Associated with this there is a hyperemia of the contiguous mucous membrane lining all of the air cells, the pneumatic structure, in the temporal bone. The hyperemia results in a temporary slight increase in the thickness of the mucous membrane. Subsequent developments, without extension of the infection into the mastoid or petrous portions, may result in a further displacement of the air from the pneumatic cells by an added increase in the thickness of the mucous membrane because of the congestion, diapedesis and the formation of a transudate. A roentgen examination at this time reveals a diminution in the aeration of the pneumatic structure of the mastoid process and the petrous pyramid. The greatest diminution in aeration is noted in the antrum area. As the lesion progresses, the cell walls appear thick

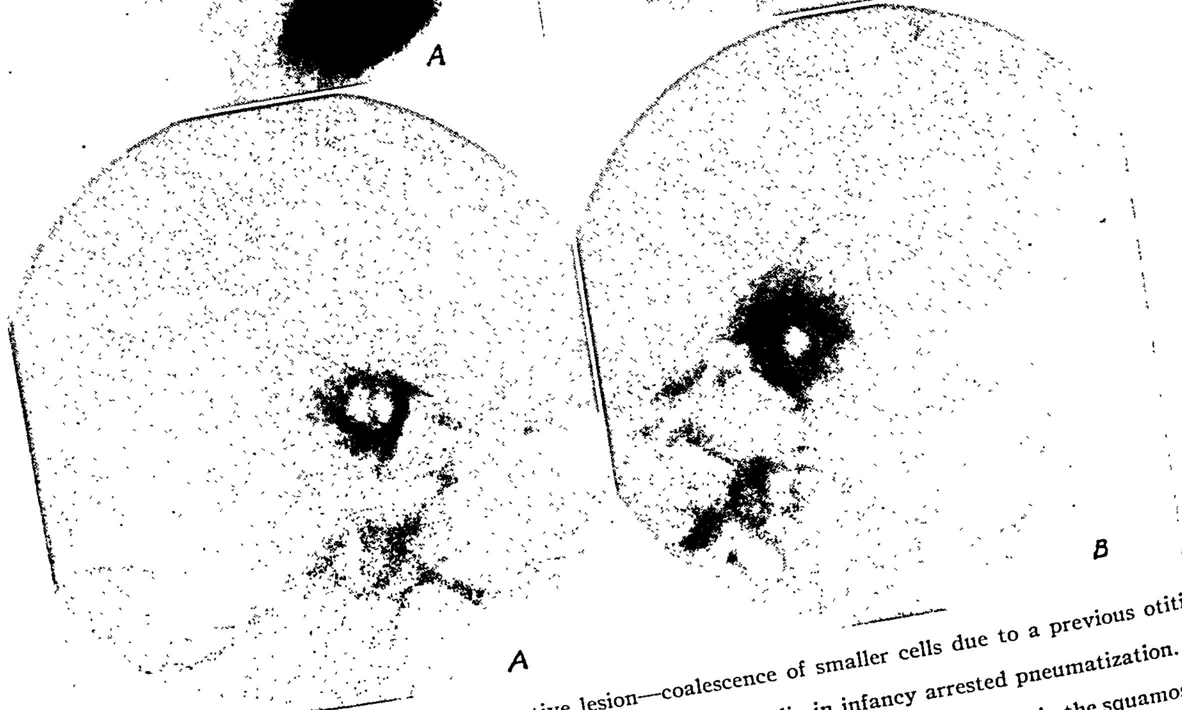

Fig. 2-*A* (*upper left*). Localized destructive lesion—coalescence of smaller cells due to a previous otitic infection.
Fig. 2-*B* (*upper right*). Incomplete pneumatization. Otitis media in infancy arrested pneumatization.
Fig. 3-*A* (*lower left*). Large, normal well developed mastoid.
Fig. 3-*B* (*lower right*). Diminished aeration. Decalcification and destruction of cell walls in the squamosa, supra- and post-sinal regions. Sinus wall distinctly visualized and intact. Destructive mastoiditis.

and less sharply defined. The contrast between the cell wall and the air cell is less marked. The density of the mastoid is increased. The sinus wall becomes visible.

As the otitis media resolves there is a gradual return to normal. If, instead of resolution, the infection extends into the mastoid process and produces a destructive lesion, the roentgen findings on serial study will show the development of the matic areas. Rarely is the petrous pyramid involved simultaneously.

All acute otitic infections, regardless of their type or location, will produce a decrease in aeration when compared with the healthy side. Consequently one cannot base an opinion on a variation in density alone. Only intramastoidal diseases will cause a partial or total destruction of the intercellular structure. Bearing this in

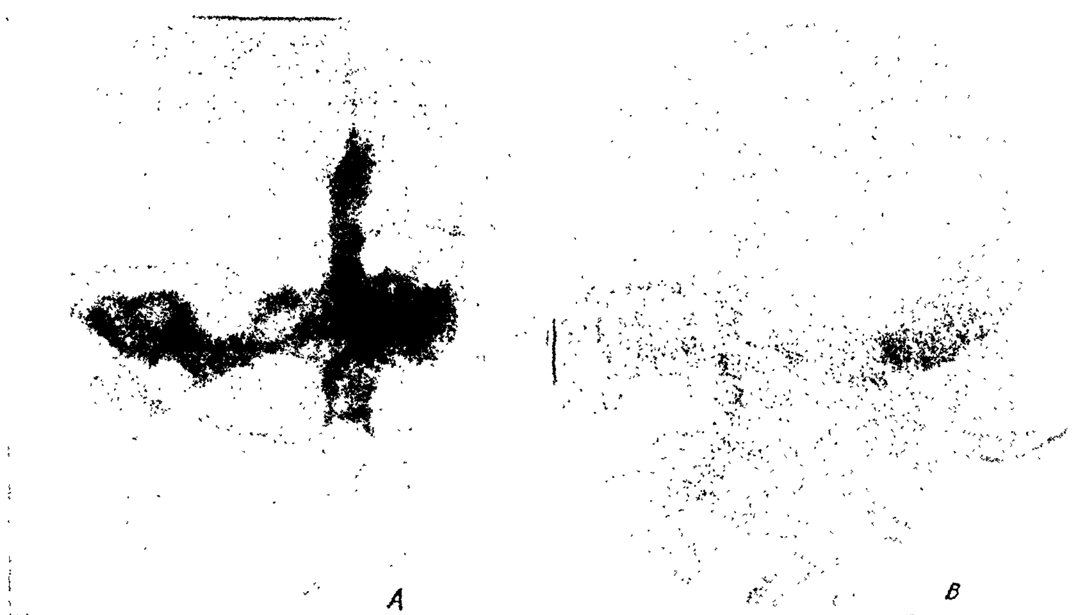

Fig. 4-*A*. Normal petrous pyramid. Superior margin intact.
Fig. 4-*B*. Localized decalcification of superior margin extending forward from subarcuate fossa into apical-carotid portion of pyramid. Epidural abscess.

destructive lesion. The hyperemia persists, the transudate becomes an exudate, and the air cells contain all the products of inflammation. Even though an aural discharge is present, drainage is not adequate. The cell walls begin to lose density, due to the hyperemia and increased intracellular pressure. There is gradual decalcification, softening, and breaking down of the cell walls. Granulations develop. If permitted to continue, a large coalescent abscess forms. The sinus wall and tegmen are dense and appear intact. Dehiscences or destructive changes in the sinus wall or tegmen denote complications. Perforation may occur at the tip, or subperiosteally in the mastoid, squamous, or zygo- mind, the classification of mastoid diseases from a roentgen standpoint into those which destroy structure and those which do not, becomes evident. A diminution in the aeration of the mastoid process, with intercellular walls and all other anatomical landmarks remaining intact, will also be found in furunculosis, post-auricular adenitis, and cellulitis.

It is an established fact that with every acute purulent otitis media there is a concomitant hyperemia or edema in the mastoid process. Just when an acute purulent otitis media becomes an acute mastoiditis must be left to the otologist. From the roentgen standpoint, it is not known whether a diminution in aeration of the

mastoid process, with intact cell walls, is due to an acute purulent otitis media or an early acute mastoiditis of a surgical nature. small-sized mastoid process, as seen on the roentgenogram, will warn the otologist of the possibility of an erosion of the inner

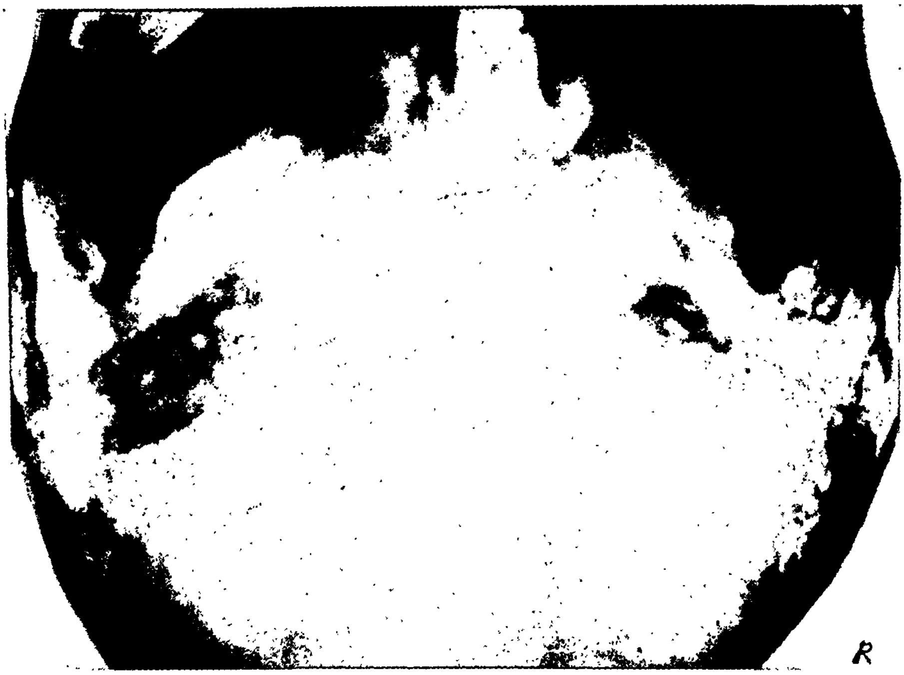

Fig. 5. Right petrous pyramid—normal. Complete pneumatization of apical-carotid portion. Labyrinthine area shows considerable cellular development.
Left petrous pyramid—Complete destruction of all cell walls in the apical-carotid portion. There is a marked diminution in aeration of the cells in the labyrinthine area. Suppuration in apical-carotid portion of pyramid. (Clinical—drainage inadequate.)

There is one type of acute mastoiditis wherein the cell walls remain intact—the acute hemorrhagic mastoiditis. This lesion presents numerous small punctate areas of atrophy in the cell walls and a diminution in aeration. The cell walls are intact throughout the entire course of the disease.

As a rule, the size of the mastoid as determined in a roentgenogram is of little value to the clinician. It becomes important, however, in those cases of protracted acute purulent otitis media in which, in spite of the absence of all systemic and local symptoms, the otological picture is that of an acute mastoiditis. In such a case, the finding of extensive pneumatization toward either the squamosa, zygoma, occipital bone, or petrosa, or all of these regions, informs the otologist that extensive destruction must take place before local and general symptoms are manifested clinically. On the other hand, a table, if operation is delayed too long, in a protracted case.

Resolution in mastoid infections occurs with considerable frequency. All acute infections do not produce large coalescent abscesses requiring surgery. At times, an infection from an otitis media extends into the mastoid, produces one or more localized areas of destruction, and then resolves.

In any one individual, the mastoid processes are usually of the same size and type. Consequently, in a pneumatic mastoid there should be the same cellular development and distribution in both mastoids. However, the size and position of the cells are important only in a comparative way. Where in one area of the uninvolved mastoid one finds small cells, and where in the same area in the involved mastoid large cells are present, it is significant of a destruction of the intercellular septa in this location, resulting in the formation of large

cells from the coalescence of smaller ones. This may be the end-result of a previous otitic infection.

An extension of the infection into the petrous pyramid may occur with an otitis media, or a mastoiditis, or both, or appear as a complication following surgery. The structure of the pyramid may be pneumatic, non-pneumatic, or a combination of both.

Suppuration in the apical-carotid portion of the petrous pyramid may occur in any type structure of bone. If the petrous pyramid is composed of diploic bone, an osteomyelitis results. When pneumatization is present, changes result which are analogous to a suppurative lesion in a pneumatized mastoid process—a coalescent petrositis or an empyema.

Roentgenographically, the pneumatic petrous pyramid shows a change from the normal with any otitic infection, and is observed as follows:

1. *Acute Purulent Otitis Media.*—The petrous pyramid shows a generalized diminution in aeration. The trabeculæ appear thickened and are intact. There are no destructive changes. There is no atrophy. The apical contour is distinctly visualized and is intact. This accompaniment to an acute otitis media is not due to a suppurative lesion in the petrous pyramid. The diminution in aeration of the petrous pyramid is due to a congestion and edema of the mucous membrane lining the air spaces. The mastoid process is the site of a similar change in aeration at the same time. The change in aeration of the pyramid is so pronounced when compared to the normal side, that the diseased ear can be detected from the appearance of the petrous pyramid.

2. *Acute Coalescent Mastoiditis.*—The petrous pyramid also shows a diminution in aeration when there is an extension of the infection from the middle ear into the mastoid process, resulting in a destructive or coalescent mastoiditis. The findings are essentially the same as those found with an acute otitis media; they are more pronounced, because the congestion and edema in the petrous pyramid are more marked. There is a marked decrease in aeration, a generalized increase in density. The trabeculæ, while thickened, show *no evidences of softening or destruction.* There is no atrophy, and the contour of the apical-carotid portion of the pyramid is visualized and is intact. These changes do not indicate a suppurative lesion in the petrous pyramid. Even after mastoidectomy for a coalescent mastoiditis, the petrous pyramid will show a similar change, until there is complete restitution to normal.

3. *Chronic Suppurative Otitis Media.*—The petrous pyramid shows a generalized diminution in aeration where a pneumatic petrosa is found. However, a pneumatized pyramid is the exceptional rather than the usual finding in the presence of a chronic purulent otitis. There is no atrophy and there are no destructive changes. There is no infection in the petrous pyramid. The diminution in aeration is due to the attendant congestion and edema of the mucous membrane, when present. A cholesteatoma does not enter into the discussion for it does not occur in a pneumatic bone.

4. *Suppuration in the Apical-carotid Portion of the Petrous Pyramid, with Inadequate Drainage.*—The petrous pyramid shows a diminution in aeration with an increase in density in the basal or labyrinthine portion. The apical-carotid portion of the petrous pyramid shows a marked decrease in density. There is a marked decalcification of the entire medial portion. The trabeculæ may show evidences of softening or destruction, these changes becoming more pronounced as the lesion progresses. The halisteresis may be so intense that the contour of the apical-carotid portion is visualized either faintly or not at all. The fact that the contour of the apical-carotid portion of the petrous pyramid is not visualized does not indicate perforation. As the lesion progresses, perforation and destruction of the apex may ensue. These changes are quite striking, and the demarcation between the apical-carotid and labyrinthine portions is definite and pronounced, and due to a suppurative

lesion in the apical-carotid portion of the petrous pyramid—an empyema. If drainage from the suppurative lesion is inadequate, the roentgen findings accompany a given symptom-complex, and surgery is required to avoid an intracranial complication. This lesion is an acute one, and surgery is necessary as a life-saving measure.

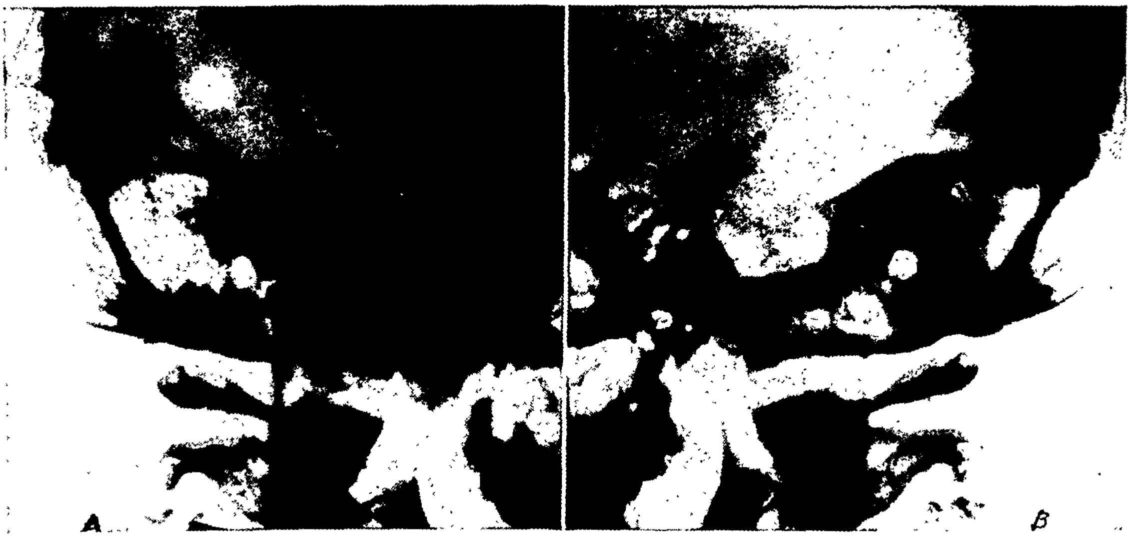

Fig. 6-*A*. Normal petrous pyramid.
Fig. 6-*B*. Clinical and roentgen examinations: suppurative lesion in apical-carotid portion of petrous pyramid. The contour of the apical-carotid portion of the pyramid is not visualized, due to complete decalcification.

5. *Suppuration in the Apical-Carotid Portion of the Petrous Pyramid, with Adequate Drainage.*—The changes in the appearance of the pyramid are essentially the same as those described when drainage is inadequate. The demarcation between the apical-carotid and labyrinthine portions may not be so pronounced. The basal portion of the pyramid shows a decrease in aeration, an increase in density. The trabeculæ may be partially or completely softened or destroyed. The apical-carotid portion is decalcified. The contour of the apical-carotid portion may or may not be visualized. The spontaneous institution of adequate drainage, development of a fistulous tract wide enough to permit drainage, through the middle ear or wound, modifies the clinical picture, and may prevent an intracranial complication. This lesion may continue and be the cause for a persistent otorrhea. This lesion can be considered as subacute, for drainage is adequate and surgery as a life-saving measure is not necessary. It is possible for inspissated pus or granulation tissue to occlude the fistulous tract and interfere with drainage. When this happens, the clinical picture is that of an acute type process as described in the foregoing paragraph. It is conceivable for a given case to present alternately periods with grave symptoms and periods of well-being; in other words, to oscillate between the acute and subacute from the clinical standpoint, even though the roentgen findings are identical. Cases with adequate drainage may go on to spontaneous healing.

6. *Suppuration in the Apical-carotid Portion of the Petrous Pyramid—Persistent Otorrhea.*—After mastoid surgery, a number of cases have a persistent otorrhea. Some of these have the source of the infection in the petrous pyramid. These pyramids show a generalized diminution in aeration, with a generalized increase in density. There is a partial sclerosis of the pyramid—productive osteitis secondary to the infection in the petrous pyramid. The remaining trabeculæ become markedly thickened. These reparative changes are superimposed upon the original destruc-

tive lesion. This lesion may follow an otitic infection without mastoid involvement as well as an empyema in the apical-carotid portion with adequate drainage, in instances in which there has been a destruction of the trabeculæ. There is no restitution of trabeculæ, there is no redevelopment of air cells, but there develops a productive bone change secondary to the infection in the petrous pyramid.

7. *Healed Suppurative Lesion in the Petrous Pyramid.*—The petrous pyramid shows a generalized increase in density. Restitution occurs by a productive bone change. The pneumatic structure is replaced by dense compact bone. There is no reformation of cells.

The roentgen findings in the above illustrated types of otitic infections may be divided into two main groups. First, those types which show halisteresis of the apical-carotid portion of the petrous pyramid, of which there are two; and second, those types which do not show halisteresis of the apical-carotid portion, of which there are five. A suppurative lesion in the apical-carotid portion of the petrous pyramid is present in the two types which show halisteresis, and in only one type showing an increase in density—a productive bone change.

The suppurative lesion in the apical-carotid portion of the pyramid, depending on the history, clinical and roentgen findings, may be designated as either acute, subacute, or chronic.

1. *Suppuration in the Apical-carotid Portion of the Petrous Pyramid—Acute.*—The history is usually that of a simple mastoidectomy on an extensively pneumatized bone followed by a normal convalescence. After a period of well-being—which may be from a few days to several weeks and sometimes months—there is a sudden reappearance of an aural discharge, a low grade sepsis, and pain along the ophthalmic branch of the fifth nerve. The pain is usually located in or behind the eye. This symptom-complex was described by Kopetzky and Almour, and is due to the inadequate drainage of the abscess or empyema in the apical-carotid portion of the pyramid. At operation, several cases showed fistulous tracts which did not permit adequate drainage. A roentgenogram shows findings as previously described under suppuration with inadequate drainage (paragraph 4, above). This type of case requires immediate surgical intervention. It is the only type which is of immediate concern to the otologist, for, if left alone, an intracranial complication with a fatal outcome is certain to follow.

2. *Suppuration in the Apical-carotid Portion of the Petrous Pyramid—Subacute.*—The persistence of an aural discharge following a recent simple mastoidectomy on a pneumatized mastoid is the history usually obtained. There may be no clinical symptoms other than an otorrhea. A roentgenographic examination reveals the changes described above under suppuration with adequate drainage (paragraph 5, above). Here a fistulous tract is present which adequately discharges the contents from the apical-carotid portion of the pyramid externally. When drainage is adequate, surgery as a life-saving measure is not necessary, but should be undertaken if a chronic otorrhea is to be avoided. The symptom-complex described by Kopetzky and Almour is absent.

3. *Suppuration in the Apical-carotid Portion of the Petrous Pyramid—Chronic.*—A history of mastoid surgery may or may not be present. The usual history is that of mastoid surgery, followed by a persistent otorrhea, and often there is a history of one or more revisions. The roentgen findings are those described under suppuration with persistent otorrhea (paragraph 6, above).

From the foregoing it is quite apparent that a history of the case is essential to the correct interpretation of the roentgen findings in the petrous portions of the temporal bone, irrespective of the nature of the otitic infection—whether it be acute, subacute, or chronic. Many cases may suggest petrosal suppuration, but, when subjected to careful analysis, prove not to be. The combined evaluation of clinical

symptoms by the otologist and the interpretation of roentgen findings by the roentgenologist will avoid errors in diagnosis.

Fig. 6-*C*. Lipiodol instilled into apical-carotid portion of pyramid. No evidences of perforation.

It is, therefore, of the utmost importance to remember that only those changes in the roentgenogram are to be considered as diagnostic which point to a destructive lesion. A change in density, or diminished aeration alone is not indicative of a suppurative process in the petrosa.

All cases of suppuration in the petrous pyramid, diagnosed and operated upon, may be verified at operation by the instillation of lipiodol, through the fistulous tract if present, through the drill hole made by the Almour operation, or by the procedures recommended by Eagleton or Myerson. Dr. Lempert described apicectomy, which is a complete exenteration of all the cells within the apical-carotid portion of the petrous pyramid. Only by the use of contrast substance can a perforation in the apical-carotid portion of the pyramid be definitely determined. I have seen cases in which the halisteresis was intense and perforation suspected because the apical contour was not visualized. Roentgen examination in these cases after the instillation of lipiodol showed no escape of the contrast substance from the confines of the petrous pyramid. Other cases in which the contour of the petrous pyramid was completely visualized and appeared intact, showed escape of the lipiodol into the cranial cavity. The contrast substance may escape into the anterior, middle, and posterior fossæ, and also over to the opposite side, or it may be localized at the site of the perforation.

I wish to call attention to the importance of a routine roentgenogram of the base of the skull at the time of the roentgen examination of the mastoid processes. This film is of considerable value. Should a subsequent lesion develop in the petrous pyramid, a film to detect changes by comparison is available. When a lesion is suspected in the petrous pyramid, anteroposterior oblique views, or in the Stenvers position, should be made in addition to a

film of the base of the skull. I prefer a film of the base of the skull in diagnosing suppurative lesions in the petrous pyramid. The oblique views may help to confirm or corroborate the findings of a suppurative lesion, and are also of real value in the detection of an epidural abscess in the anterior portion of the pyramid which cannot be recognized on a film of the base of the skull.

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THE PHYSICAL PRINCIPLES OF SLIT KYMOGRAPHY[1]

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THE development of the roentgen kymograph and its increasingly important position in x-ray diagnosis make it desirable at this time to correlate the physical principles underlying the method. This is peculiarly important in this field which is primarily concerned with a physical process movement.

Slit kymography is essentially a process in which an image of a moving object formed by any type of radiation is permitted to fall upon a screen opaque to the radiation and bearing one or more transparent slits. A surface sensitive to the radiation is moved past the slit, or the slit-bearing screen is moved past the sensitive surface. The developed image is the kymogram.[2]

Fundamental Considerations.—We shall designate the slit width by s (cm.) and assume that the movement of the film is in a direction at right-angles to the slit and with constant speed v (cm. per sec.). Every point of the film which passes the slit is exposed to the ray during a time equal to s/v seconds. This may be called the *characteristic time.*

Thus if the slit width is 0.4 mm. = 0.04 cm., and the speed of the film 1.2 cm. per second, the exposure of any point on the film passing the slit is equal to the characteristic time and is 0.04/1.2 = one-thirtieth second. The technical factors (kv., ma., distance, etc.) must be so selected as to produce an acceptable ordinary film of the structure studied in one-thirtieth second.

Suppose, for example, that the structure to be studied is the heart and that the opaque screen bears only one slit. The patient will be placed so that the slit crosses the projection of the heart and intersects the latter at one or two points. Let us suppose, further, that the exposure factors have been so selected that an ordinary film taken with these factors (with one-thirtieth second exposure) would show good contrast, *i.e.*, the heart shadow would be clear white and the lung-field quite black. The kymogram is made with the film moving down, let us say, at the uniform velocity of 1.2 cm. per second and the slit width is 0.4 mm. (as above). Assume further that the exposure lasts two seconds. (N.B.—This exposure would represent quite a large load on the x-ray tube since the power suitable for one-thirtieth second ordinary exposure is applied for two seconds.)

The result of such an exposure would be a kymogram appearing similar to the diagrammatic sketch shown in Figure 1. The blackened areas marked *a* have been exposed to rays which reached the film through the slit and through the relatively transparent lungs. The region marked *b* is the trace of the cardiac shadow. The regions marked *c* are unexposed because throughout the time of exposure the film in these regions was protected by the opaque portions of the slit-bearing screen. The width, or height, of the zones *a* and *b* is, of course, 2.4 cm., corresponding to the distance moved through by the film during the exposure (two seconds at 1.2 cm./sec.). The lateral borders of zone *a* bear serrations, or waves, due to the fact that the width and position of the cardiac shadow were not constant throughout the exposure but varied more or less with the heart beat.

The principal problem of kymography is the analysis of these waves in order to draw conclusions from their characteristics as to the movement of the structure under

[1] This is one of a series of papers contributed by friends and former pupils of I. Seth Hirsch, M.D.

[2] In this article our attention shall be confined exclusively to slit kymography with x-rays.

examination. In this connection, it is desirable to stress a point which has been often overlooked. The waves on the kymogram can yield directly only information regarding the movement of the *shadow*. Since the shadow does not uniquely determine the shape or size of the structure producing the shadow, a study of the movement of the shadow cannot uniquely determine the movement of the structure. However, as a result of experience, it is possible to draw clinical conclusions from a two-dimensional shadow of a structure. To this extent it should be possible, on the basis of experience, to draw clinical conclusions from an analysis of the kymographic waves.

Just as the two-dimensional shadow can yield no complete information as to the three-dimensional form of an object, so the single-slit kymogram (one-space dimension) can yield no complete information as to the two-dimensional shadow.[3] The kymogram has, however, a new dimension, *time*, so that although it is limited, as stated, it can yield full information with regard to the time course of the one-dimensional entity.

Specifically, in the kymogram of Figure 1, the waves on the right and left borders of zone *b* are complete time graphs of the movement of two points. These points are the intercepts of the shadow and the slit. In order to study the waves in such graphs, it is necessary to designate the time axis. In the case considered, time must be measured upward, since during the exposure the film moved down and the lowermost part of the exposed area was irradiated first. This is indicated on the diagram by the arrow *t*.

Thus, at the beginning of the exposure the left point (intersection between left shadow border and slit) was in the position q_1. A short time later it had moved laterally to the position q_2. Later it is in its mesial position, etc. If the record is turned so that the lower edge of the recorded zone is to the left and the left side of the film upward, we should have a graph on conventional coördinates in which time is measured to the left and

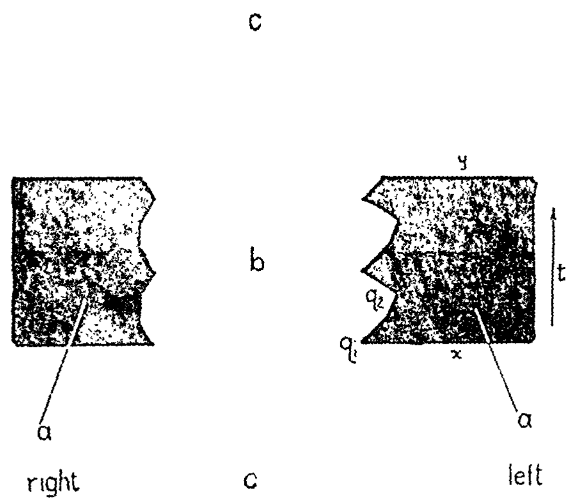

Fig. 1. A single slit-moving film kymogram (diagrammatic).

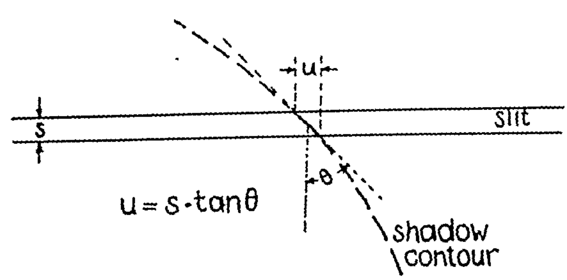

Fig. 2. Origin of obliquity unsharpness. The shadow contour crosses the slit obliquely so that a zone of width *u* is occupied by the shadow edge.

lateral displacement of the left border upward. By turning the film so that the lower edge is to the left, but the right side upward, the lateral displacement of the right border would be measured upward (time remaining to the left).

The time scale is obviously fixed by the speed of film movement. In our example, the time scale is 1.2 cm. for a second. It is the same for both the right and left borders, and points on the two curves, equidistant from the starting line (bottom), are simultaneous.

If the movement is periodic, *i.e.*, a regular repetition of similar displacements,

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[3] If the slit is moved, instead of the film, the information as to shadow shape and size may be relatively complete (scanography). In such a case, however, the time axis is not straight.

we can speak of its period and its frequency.

The period is the time between two successive identical occurrences. It is equal to the distance d between successive similar peaks divided by the speed of movement, *i.e.*,

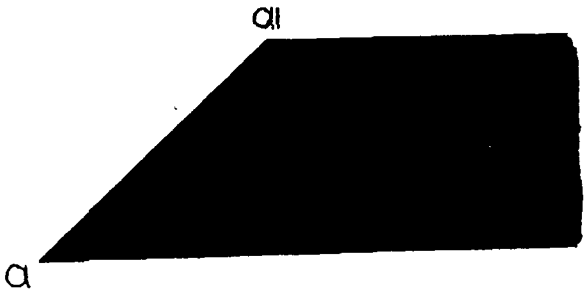
$$T = \frac{d}{v}.$$

The frequency is evidently the reciprocal of this, or with obvious symbols

$$n = \frac{1}{T} = \frac{v}{d} \text{ events per second,}$$

or

$$N = \frac{60}{T} = \frac{60v}{d} \text{ events per minute.}$$



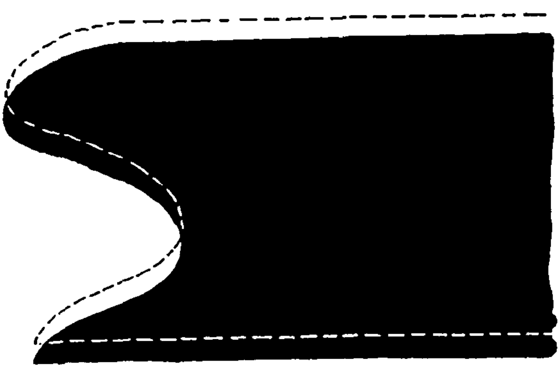


Fig. 3. (*above*). Kymogram in which the shadow edge moved with a constant velocity in a direction parallel to the slits during the exposure.
Fig. 4 (*below*). Kymogram with infinitely narrow slit, and dashed contour of kymogram of same movement, if narrow slit were displaced.

Distortion and Definition.—Since the waves are representations of the movement of points defined in relation to the shadow and the grid, they will be enlarged in the ratio of target–film to target–grid distance.[4] This enlargment refers only to the extent of displacement, not, of course, to the time axis, which is determined completely by the film speed.

The sharpness of the waves will depend in the first place upon the usual factors determining sharpness, such as focal-spot size, ratio of object–film to object–tube distance, screen grain, screen contact, etc. It will also depend in the usual manner upon the degree of contrast, so that a contrasty film will give the impression of greater sharpness.

In addition, there is a type of unsharpness which appears only in the kymogram. It may be called *obliquity unsharpness* and is produced when the border of the shadow is not perpendicular to the slit. In Figure 2, the distance u represents the width of a zone of unsharpness due to the obliquity of the shadow edge to the slit. Obviously, $u = s \tan \theta$.

A further type of unsharpness appears at the edges of the band (x and y, Fig. 1), due to the fact that since the film is moving at the start and at the end of the exposure, a zone equal in width to the slit s at both start and finish of the exposure cannot receive the full amount of radiation. Points on the film near the bottom of the slit (film moving down) at the start of the exposure, and those near the top at the end of exposure do not receive as much radiation as do those between. If the slit-bearing screen is close to the film and perfectly opaque, the width of the film receiving some radiation will be the ideal width (film velocity × exposure time) increased by the slit width s.

Consider, now, the appearance of a kymogram at the edge of a shadow, perpendicular to the slit so that there is no

[4] Note that the waves are defined in relation to the grid. Without the slits there would be no waves. The latter have no independent significance. The enlargement here given does not take into account the fact that the shadow itself is an enlarged projection of the object. From the point of view here taken, the shadow is the object the motion of which we are studying.

obliquity unsharpness, moving with a constant speed v in a direction parallel to the slit. Assume, for simplicity, that the shadow is perfect (*i.e.*, no energy reaches the film when inside the shadow). The resulting kymogram would have the appearance indicated in Figure 3. The straight edge a, a^1 indicates a movement of uniform speed. Even if we assume all the causes of unsharpness heretofore mentioned to be inoperative, the edge a, a^1 cannot be sharp.

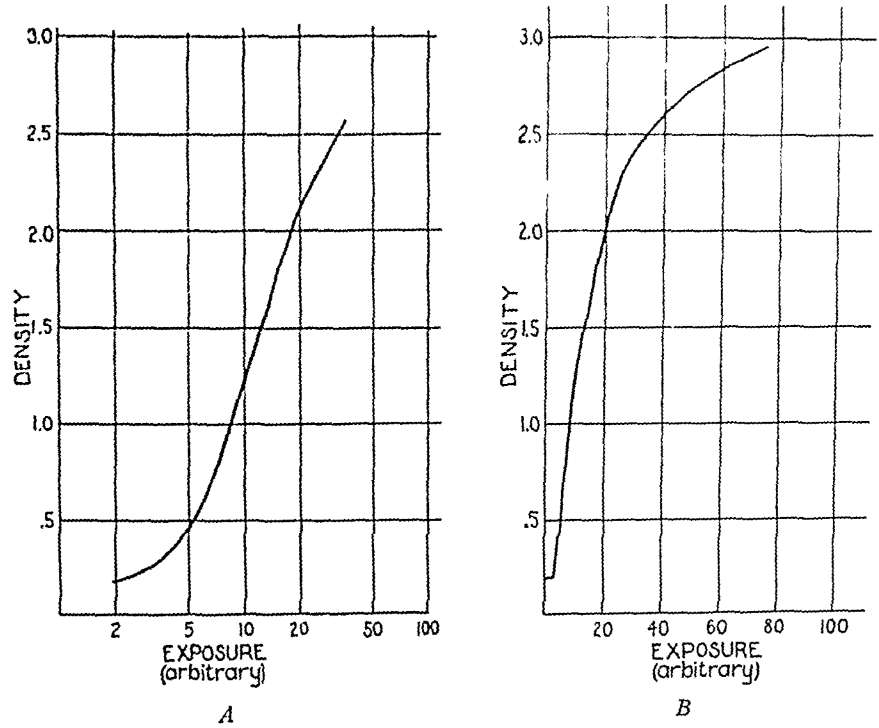


Fig. 5. Relation between density and exposure. *A*. On logarithmic scale; *B*. On linear scale. (These curves are taken from data for double-coated film in screens, kindly provided by Mr. R. B. Wilsey, of the Eastman Kodak Company.)

Perfect sharpness of this edge would imply that every point of the film received either no energy or that corresponding to an exposure for the characteristic time. Such a condition may easily be shown to be impossible. Consider a point in the film at the center of the slit at the time the shadow uncovers it (or occludes it). This point must receive an exposure of half the characteristic time. Points higher up on the film at the moment of uncovering (or occluding) will receive more (or less). Only points which traverse the slit without any change occurring will have either none or the full exposure; these are points inside or outside the shadow, but not near the moving edge at any time. Thus, the edge representing a moving shadow must have movement unsharpness of magnitude equal to s. This represents a *time unsharpness* of magnitude s/v. No event in the kymogram can thus be timed directly with absolute accuracy. There is a time unsharpness of amount s/v which is equal to the characteristic time.

It is interesting to consider somewhat more closely the actual course of time unsharpness. Figure 4 shows a record of a particular movement which would be obtained if the slit were infinitely narrow, *i.e.*, with no movement unsharpness, and if this infinitely narrow slit is considered to be located at the bottom edge of the real slit. The dashed line indicates the

edge of the record which would be obtained if the imaginary slit were located at the upper edge of the real slit. The vertical distance between these two imaginary records is equal to the slit width. The zone between them is the region of time unsharpness in an actual record. This zone will appear somewhat like the penumbra of a shadow, shading off between the illumination of the two regions of low and high photographic density.

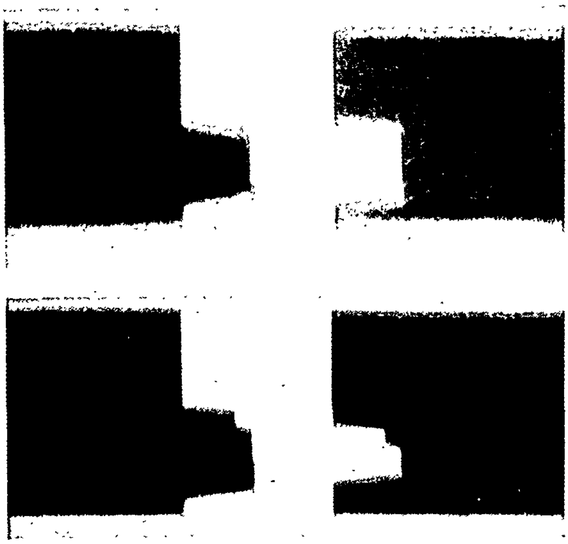


Fig. 6. Kymogram taken of an object moved as indicated. The slit width is one-fifth of the record length. Note that events on both sides, really simultaneous, do not appear to occur at the same time. This is attributable to the non-linear (logarithmic) response of the photographic material.

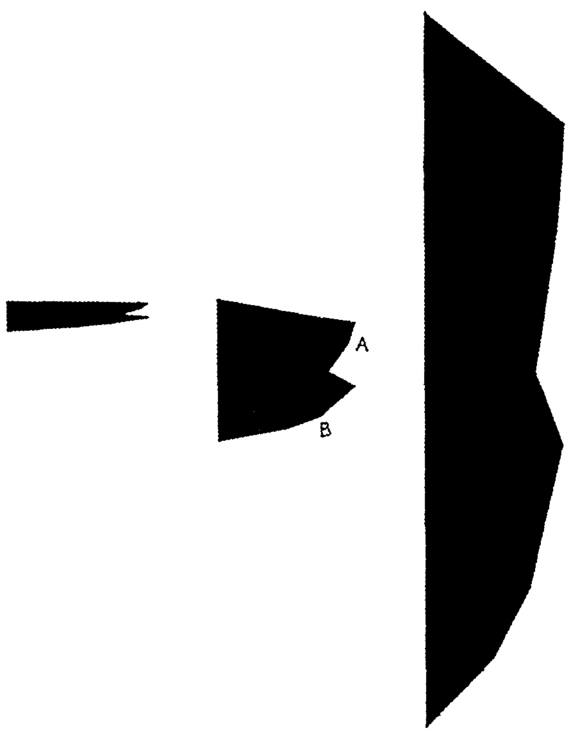


Fig. 7. The *esthetic* relation. The changes in velocity observable in the middle record at A and B are not both as clearly seen in either of the two records at right and left. The three records are identical, except for the time scales. In the middle record this is so selected that the length of the wave (time scale) is equal to its amplitude.

If the movement to be recorded is so rapid, the film speed so slow, or the slit width so great, that the zone of unsharpness is as great or greater than the width of the ideal wave (infinitely narrow slit), then the entire wave will be enclosed in a zone of unsharpness, and measurements of time or duration will become impossible. This limit on the duration of a wave, below which it cannot be recorded with any precision, is called the *resolution* of the kymogram. A rough index to this quantity is obviously the characteristic time, which is of the same order of magnitude. This difficulty cannot be overcome by magnification of the film photographically or optically. The unsharpness would be magnified together with the rest of the image. No closer time measurement could be obtained. This situation is similar to that presented by ordinary radiography, in which the unsharpness due to focal spot size does not permit the accurate delineation of detail. Enlargement cannot help put details in an image where they do not exist.[5]

This time unsharpness corresponds, in a rough way, to the effects of instrumental inertia in recording instruments. The physiologist is accustomed to indicate the limit of time accuracy of any type of recorder by stating its natural frequency or natural period. Although an instrument will respond to impulses which occupy less time than the natural period, they do so with great distortion. For this reason the natural period is usually regarded as setting a limit. An instrument is not to be depended upon for the recording of events

[5] This is generally true when the details lost are of greater size than the resolving power of the eye. In roentgenography this is usually the case.

which occupy a time smaller than the natural period.

Since there is nothing corresponding to inertia[6] in the roentgen kymograph, there can be no natural period. The resolution is nevertheless limited, so that events occupying a time smaller than the characteristic time are not properly recorded. Thus the characteristic time of a kymogram may be considered as analogous to the natural period of other types of recorders.

It is important to note that the characteristic time as a limit for the resolution obtainable is somewhat stringent. Actually, since the photographic response is logarithmic, the unsharpness zones are narrower than the slit width.

In the zone of time unsharpness (neglecting all other types of unsharpness), the exposure actually received by any point on the film is a linear function of the distance of that point from the ideal (infinitely narrow slit) position. The photographic density resulting is a logarithmic function of the exposure, indicated by the well-known photographic sensitivity curves, an example of which is shown in Figure 5-*A*.

Figure 5-*B* shows the same relation plotted on linear scales. In the time unsharpness zone, the width of which is always equal to that of the slit, the density thus varies, not linearly, but starting at the side of higher density, the density varies slightly at first and then more sharply, thus giving the appearance of a narrower unsharpness zone, and a sharper transition from the unsharp zone to the region of low density. If the density of the darker side of the zone is very low, the low density cut-off (background fog) will narrow the unsharpness zone on the low density side.

The effect just discussed thus tends to narrow the zone of unsharpness somewhat, and to produce an apparent sharper edge. This apparent sharp edge is, however, not at its theoretical location but displaced, generally toward the side of lower photographic density. Figure 6 shows two kymograms of an opaque object which, during the course of the exposure, was given a single rapid to-and-fro movement. The slit width was 4.5 mm. Events on either side of the strip are obviously simultaneous, yet the waves on either side do not appear so. The difference is accounted for by the effect described.

The obliquity unsharpness discussed above enters also to produce additional time unsharpness. The obliquity unsharpness represents a zone of width $s \tan \theta$, measured parallel to the slit. If the movement of the shadow edge has a velocity V, the edge of the wave will make an angle, ϕ, with the normal to the slit, where $\tan \phi = V/v$ (v = film velocity) and the time unsharpness due to this cause will be given by

$$\frac{u}{v \tan \phi} = \frac{u}{V}$$

or

$$\frac{s \tan \theta}{V}.$$

A true measurement of a wave on the kymogram is thus in doubt by an amount equivalent approximately to the characteristic time, increased by a variable amount dependent upon obliquity, the velocity of shadow movement (parallel to slit), and the actual slit width. A partial correction may be made in certain cases, if account is taken of the unsharpness zones and their structure.

Moving Slit.—The moving film method gives a result from which conclusions may be drawn as to the movement of the portion of the shadow intercepted by the slit. The moving slit method is not susceptible to this simple analysis. Since the slit is not stationary, the record is that of the variations in the intercept of the shadow on a varying line—the moving slit line.

Such records are more complicated, yielding information not only as to movement, but also as to shape of the shadow. In general, the waves due to movement

[6] The time lag of intensifying screens may come in this category, but has not been found to be of significance in clinical kymography.

will be superposed upon the shadow contour, and not be true time graphs of the motion.

The factors influencing unsharpness, etc., are essentially the same for the moving

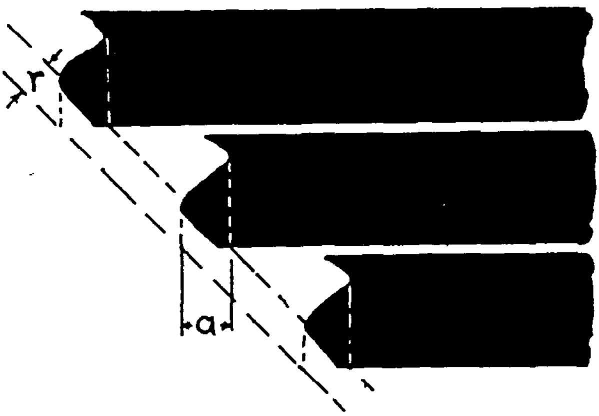


Fig. 8. *Real* and *apparent* amplitude, *a* is the *apparent* amplitude and *r* the *real* amplitude. The diagonal lines are drawn through the projection of the peaks on the bottom edges of the bands.

grid as for the moving film. For accurate time analysis, the moving film method is definitely preferable. The further discussion in this paper will be limited to the moving film method.

Density Waves.—In the kymographic exposure at the basis of the discussion up to this point, it was supposed that the technic was selected so as to produce a very contrasty result. The shadow region in Figure 1 was to be imagined completely unexposed.

If the technic were so selected that the shadow region is penetrated, other features appear on the kymogram. In addition to the contour waves, there will appear bands of varying illumination in the shadow. These correspond to the varying density of the object casting the shadow, or, more strictly, to varying intensity of the beam coming through the slit. Such variations are most commonly due to variation in width of the section of the object cut by the plane containing the slit and the tube focus. If the width of this section measured along any ray varies with time, then that ray will produce a varying illumination of the film.

It is often difficult to evaluate such films with the unaided eye, since the eye is insensitive even to relatively large differences in density, unless those differences are separated by a sharp edge. In kymograms, the density waves may be barely visible, or not even noticeable, and still represent considerable change in density. This will especially be the case if the changes are not very rapid, relative to the time scale (v) of the record.

The density waves can be studied more accurately by use of a recording densitometer. The densitometer is a device in which a narrow pencil of light is passed through the film. This light beam acts upon a photo-electric surface. The photoelectric current is then used to operate a recorder to produce a record of the intensity of the transmitted light. As the film is moved, the recording surface of the instrument is also moved proportionately, so that a record of the relative transparency of the film may be made along any line. If the line is chosen parallel to the time axis, the instrument converts the density wave into an actual time curve which can be studied to better advantage.

The density waves are representative of the changes in intensity of the x-ray beam striking the film within the shadow. Such changes are frequently due to changes in dimensions of the shadow-casting structure, or to changes in its position by virtue of which different thicknesses come into the focus-slit plane.

Thus the single-slit kymogram with density waves gives information with regard to two dimensions. The information is scanty, however, since many possible types of movement may produce the same kind of record.

The density waves, even when recorded by an accurate (narrow beam) densitometer, suffer from defects similar to those which occur in the contour waves. The existence of a finite characteristic time introduces an indefiniteness in time meas-

urements, similar to those discussed above for the contour waves.

These defects cause an error in time measurement. While, with the densitometer, there never need be any doubt as to the actual value of the illumination at any point of the film (comparable to the doubt as to the actual position of the edge of the contour wave), nevertheless, the course of the density variations are not true reflections of events. The waves recorded by the densitometer show a slurring of sharp changes due to slit width. There is also a time shift due to the slit width.

Technical Factors.—The length of record is limited by the available length of film and by the total quantity of x-rays which may practically be used. If the length of record is denoted by l, the duration by T, and the film speed by v,

$$T = \frac{l}{v}.$$

The characteristic time τ is given by s/v so that

$$T = \frac{l\tau}{s}.$$

Experience has shown that, in general, the best value of v would be one for which the waves produced have a wave length of the same order of magnitude as the amplitude. This point is well illustrated in Figure 7. This condition, while by no means an absolute requirement, if fulfilled, provides records of easy legibility.[7] If a is the amplitude of the expected waves and f their frequency, this means that

$$v = af.$$

This relation may be called the *esthetic relation*, and can rarely in practice be fulfilled for more than one wave at a time. The condition is applied for the waves of greatest interest.

The duration of the record T must be great enough to depict the entire process. Hence, if $T = N/f$, it is insured that N complete cycles will appear on the record.

The value of T determines the power which can be applied to the x-ray tube, since for every tube there is a maximum time for which any amount of power may be applied. The power is proportional to kv.p. $\times$ ma. Hence, T determines this product. The part radiographed, as in conventional radiography, determines the kv.p. to be used and the ma.-sec. for the characteristic time. The ratio of kv.p. $\times$ ma.-sec. as determined, to the power, determined from T, gives the characteristic time τ which must be used. From the probable value of a, v may be determined with the help of the esthetic relation: s and l follow from the relations above.

The process may be demonstrated by considering several practical cases.

(1) *The Heart.*—Its frequency may be taken approximately as one cycle per second, and amplitude (over the ventricle) at 1 cm. If it is desired to depict one complete cycle, $T = 1$ second. For a particular tube, operating conservatively, 10,000 kv.p. $\times$ ma. is the power capacity for one second. At 30-inch distance, a satisfactory conventional roentgenogram of the heart requires 70 kv.p. and 3 ma.-sec. a product of 210 kv.p. $\times$ ma. The characteristic time is thus fixed at $210/10{,}000 = 0.02$ second. From the esthetic relation $v = 1$ cm./sec. Hence $l = 1$ cm. and $s = 0.02$ cm.

(2) *The Contrast-filled Stomach.*—The frequency of movement may be taken as $^1/_{30}$ (*i.e.*, 30 seconds for a cycle) and the

[7] This requirement may be justified mathematically. It can be shown that small, sudden changes of velocity, which record as breaks in the kymographic wave, will be most clearly evident on a portion of a wave which makes a 45° angle with the slit line. The proof of this point is as follows: Let V_1 and V_2 be the velocity just prior to and just after the break. The angles with the normal to the slit line of the recorded edges for these velocities are, respectively, arctan V_1/v and arctan V_2/v (v = film velocity). The angular difference, or the sharpness of the break, is given by the difference between these angles, or arctan $(V_2 - V_1)\,(v/(v^2 + V_1V_2))$. Since V_1 and V_2 are assumed nearly alike, this expression reduces to arctan $(V_2 - V_1)(v/(v^2 + V^2))$ (dropping the subscript in the denominator). This quantity is a maximum when $v = V$ or $\theta = 45°$. Obviously, this condition cannot be met for all parts of a wave, but if the esthetic requirement is fulfilled, a large portion of the wave will be nearly at this angle

amplitude as about one centimeter. Hence, for one cycle, T = 30 seconds. A suitable tube has a capacity of 3,500 kv.p. $\times$ ma. for this time. A good conventional

Fig. 9-*A*.

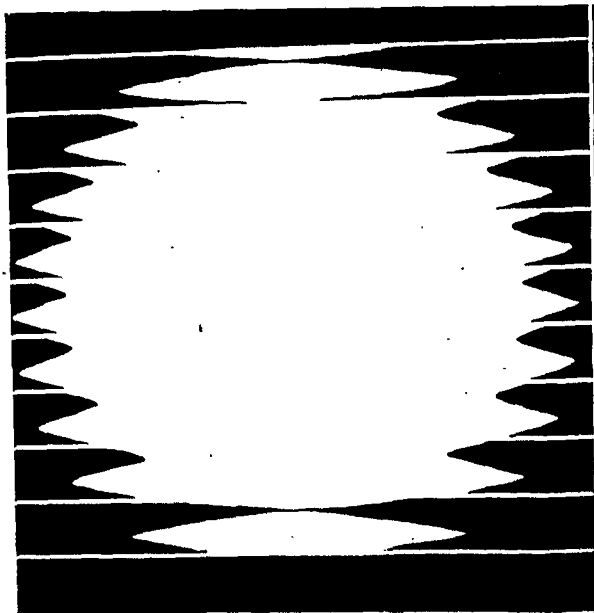
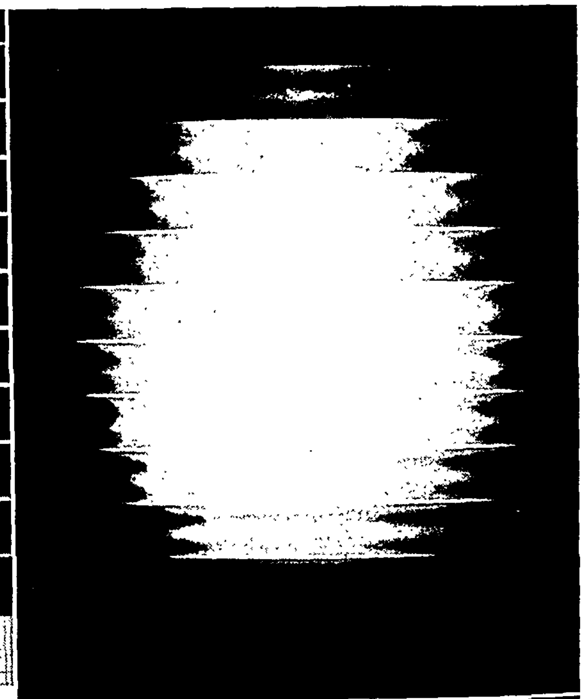


Fig. 9-*B*.



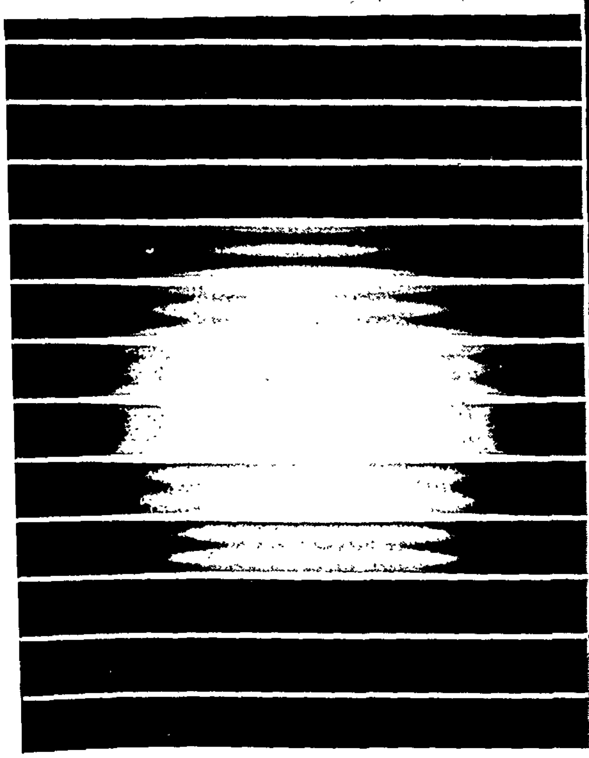


Fig. 10.

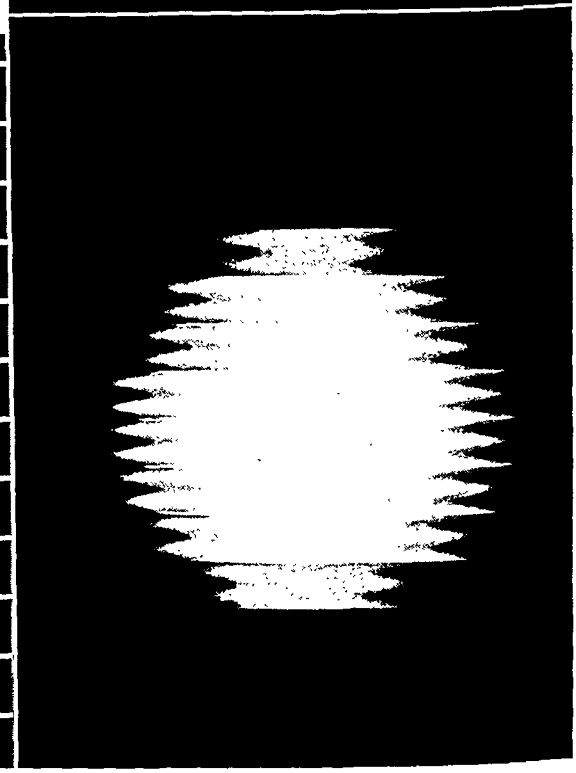


Fig. 11.

Fig. 9. Kymograms of a rhythmically expanding and contracting sphere. *A*. Computed kymogram for a sphere changing its radius rhythmically (Case 1); *B*. Kymogram of a water-filled balloon oscillating along a line perpendicular to film (Case 2).

Fig. 10. Kymogram of a filled balloon oscillating in a direction perpendicular to the slits, but parallel to the film (Case 3). Note the phase variations.

Fig. 11. Kymogram of a filled balloon oscillating in a direction parallel to slits (Case 4).

radiograph of the stomach at 30 inches requires about 20 ma.-sec. at 80 kv.p., or 1,600 kv.p. × ma.-sec. The characteristic time is thus limited to $1{,}600/350 = 0.5$ second. The esthetic relation gives $v = 1/30$ cm./sec. so that $l = 1$ cm. and $s = \tau/v = 0.017$ cm.

The slit width found for both these cases is narrow, compared to the thickness of a reasonable lead screen. If the screen were made of lead 1 mm. thick, these slits would have a scatter clean-up action corresponding to a Bucky ratio of 5:1. Such a strong clean-up action would require additional exposure. This may be accomplished by increasing the slit width (and characteristic time). Thus, for the chest, with such clean-up action, we may estimate roughly that twice the power becomes necessary, so that instead of 210 kv.p. × ma.-sec., 420 are necessary. All quantities then remain the same, except for a doubling of slit width. A more accurate analysis, including in the formulæ the effect of clean-up, is not warranted as a practical matter.

Slit Width.—If we overlook the esthetic requirement, which obviously must be of secondary importance, a given characteristic time may be attained with any slit width, if only $s = \tau/v$. Is there an optimum slit width? A wide slit has the advantage that the time unsharpness due to the slit is large compared to that due to factors not associated with the grid. It has the disadvantages that it introduces obliquity unsharpness. Evidently, then, it would be best to make the slit wider than the unsharpness due to other factors, but narrow enough to keep obliquity unsharpness at a low value. A slit width of about one-half millimeter seems, in most cases, to be large enough to make unimportant the effect of other factors, and, at the same time, is small enough to make the effects of obliquity unsharpness for reasonable obliquities negligible, compared to those due to the characteristic time.

Multiple Slits.—Many methods of multiple-slit kymography have been proposed. All of them are essentially similar, in that the slit-bearing screen carries a multiplicity of slits, and all the individual records are made simultaneously on the same film. They differ principally in the arrangement of the slits. We shall discuss some of these methods, with reference only to the moving film procedures.

Parallel and Equidistant Slits.—This method was originated by Katzman, in 1928, developed in Europe principally by Stumpf, and later in this country by Hirsch and the author, among others. It is the most popular of all methods proposed and therefore warrants a detailed discussion.

In this method, the slits are arranged parallel and equidistant to each other, forming a grid. The movement of the film (or grid), during the exposure, covers a distance slightly short of that between slits. Thus each slit produces its kymogram, and, since the length of the record is less than the distance between slits, there is no overlapping of the records.

For the study of the heart and gastro-intestinal tract, approximately the same slit width and length of record is necessary for the fulfillment of the essential conditions, and the esthetic relation. A length of record of about one centimeter and a slit width of 0.04 cm. satisfies the conditions in both cases reasonably well. The standard grid was, therefore, adopted, having slits 1.2 cm. apart and 0.4 mm. wide. This provides room without overlapping, for esthetic records of either heart or gastro-intestinal tract, showing a complete cycle. The mechanical difference between the arrangements in the two cases is the velocity of movement. For the heart this is about one centimeter per second; for the gastro-intestinal tract, about one centimeter in 30 seconds.

The discussion of the sharpness and definition of the waves in the single-slit kymogram is fully applicable to the individual kymogram of the multiple-slit record. Each of the individual records has been called "band" since they appear as illuminated bands across the film.

Fig. 12.

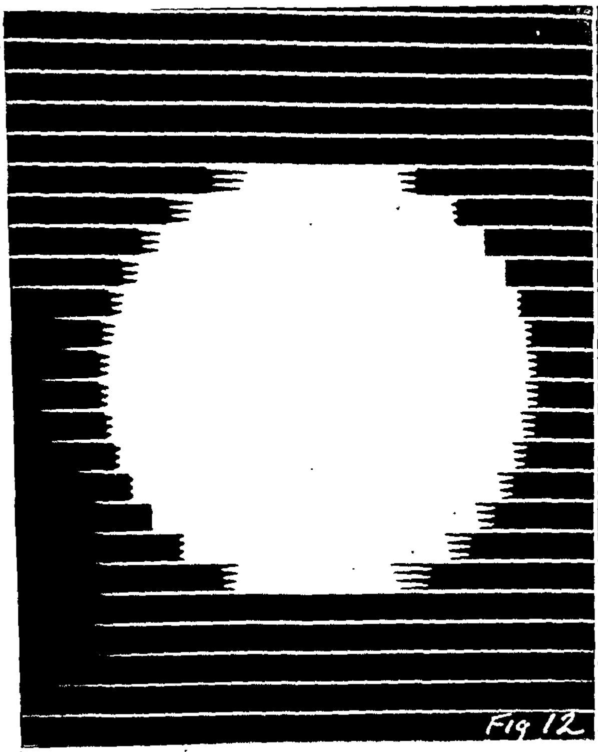
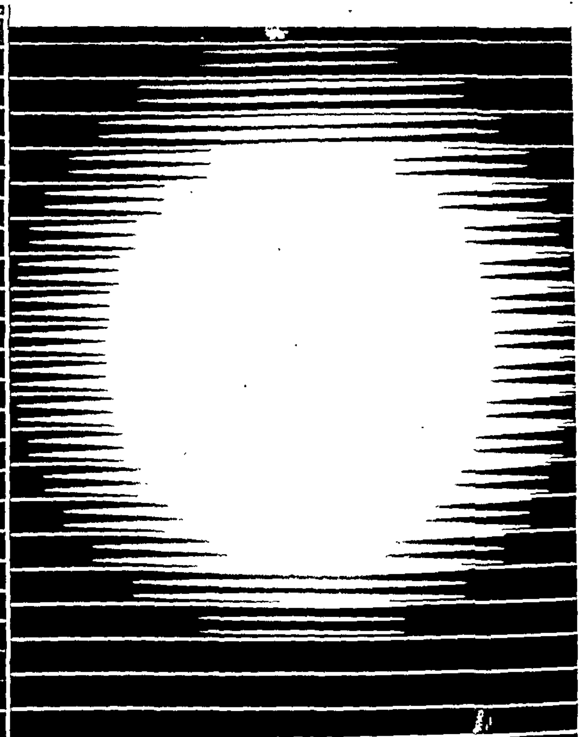


Fig. 13.



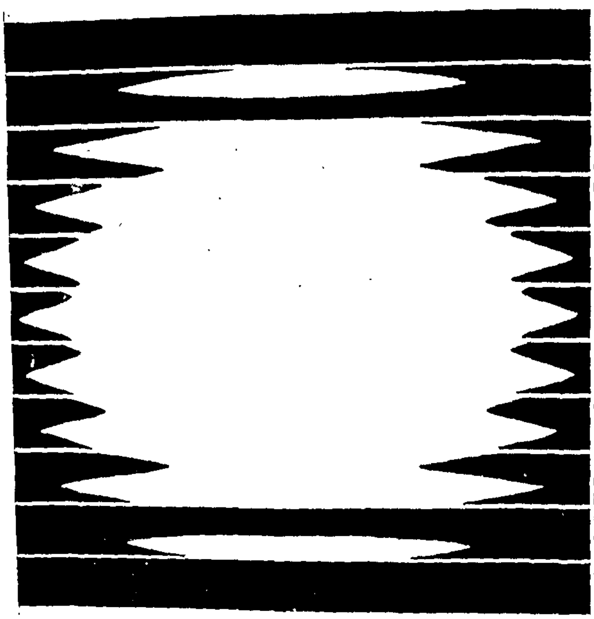


Fig. 14-*A*.

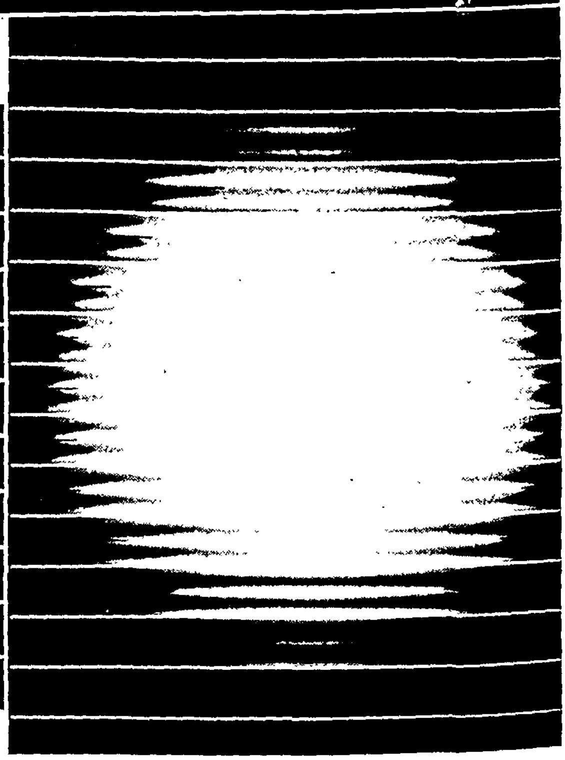


Fig. 14-*B*.

Fig. 12. Kymogram of a circular shadow oscillating at any angle to the slit (approximately 45° from upper left to lower right, Case 5).

Fig. 13. Kymogram of a circular shadow rotating about an axis not through its center (Case 6).

Fig. 14. Kymogram of a spherical object, with rhythmic variations of radius combined with oscillation about a line parallel to the film but perpendicular to the slits (Case 6). *A*. Calculated for the case in which the two oscillations are 90° out of phase; *B*. A water-filled spherical balloon performing such oscillations. The short black lines near the edges are all simultaneous. Note the phase shift.

The multiple-slit record yields more information than that of a single slit. All of the individual bands have the same time scale, hence it is possible to correlate the waves in various bands.

In the study of the kymogram, the matter of time relationship is very important. Kymographic waves are due to the movement of the shadow edge. If, as is usually the case, the film moves downward, the time flow on the record is upward. A limb of a wave which represents a lateral movement of the shadow edge may be called a lateral limb. Similarly, a limb which represents a mesial movement may be called a mesial limb. A lateral limb extends from a low (early) mesial position to a higher (later) lateral position. The point at which a lateral limb (lower, earlier) meets a mesial limb (higher, later) is called a lateral peak. The point at which a mesial limb (lower, earlier) meets a lateral limb (higher, later) is called a mesial peak.

The density variation in the shadow may be brought into a similar nomenclature. A zone of increased illumination, corresponding to a time at which the width of the section of the structure in the slit-focus plane is at a minimum, may be said to be a *contracted density peak.* A zone of decreased illumination similarly may be said to be an *expanded density peak.* In those times at which the illumination increases in the direction of time flow, there is a contracting variation of density, while when the illumination decreases, there is an expanding variation of density.

The time relationships between the various waves of a single kymogram are often expressed by the term *phase.* Thus, if two contour waves are simultaneously in their lateral and mesial limbs, the lateral and mesial peaks being at the same distance from the lower edge (start) of their respective bands, they are said to be in phase. A contour wave and a density wave are in phase if the lateral and mesial peaks of the former and the expanded and contracted peaks of the latter are, respectively, simultaneous.

Two waves are completely out of phase if the mesial (or contracted) and lateral (or expanded) peaks of one are simultaneous, respectively, with the lateral (or expanded) and the mesial (or contracted) peaks of the other.

If the peaks are not simultaneous, the waves are said to be out of phase by an amount often expressed directly in time, in particularly simple cases expressed as a fraction of the complete cycle (time between successive homologous peaks). The amplitude of a contour wave is the distance, measured in the direction of the slit, between lateral and mesial peaks. In the case of density waves, the amplitude represents the difference in illumination between an expanded and a contracted peak. It is measurable only with the densitometer and then in arbitrary units.

If the density waves near a contour wave are in phase, and if the amplitude of the density waves is great, the increased illumination simultaneous with the mesial peak may reach a level so high that the contrast at the shadow edge may be lost. The valley or mesial peak of the contour waves in such a case diffuses into the illuminated band of the density wave, and measurement of the amplitude of the contour wave may be impractical.

"Real" and "Apparent" Amplitude.—In contour waves, a distinction has sometimes been made between the *real amplitude* of the movement and the amplitude of the waves, which has been called the *apparent amplitude.* Figure 8 shows this distinction. The real amplitude, so defined, is the amplitude of movement of the shadow edge measured in a direction at right-angles to the edge. It has no more reality than the apparent amplitude, except in certain special cases. It is the quantity perceived during fluoroscopy of a moving structure.

Movement and Waves.—In general, as we have seen, it is impossible from the kymogram to draw unique conclusions as to the shape and the movement of a structure. Often we must rest content with an inductive study based on a large series of films taken on normal and abnormal individuals.

In a limited number of cases, the problem of interpretation is narrowed to a selection between certain anatomically and physiologically possible alternatives. Under such conditions, an interpretation may occasionally be made deductively. Such deductions may be simplified and clarified by a discussion of the kymograms which are produced with certain simple mechanical structures and movements. For this purpose a study was made of such situations. In the real application, conditions will rarely be as simple as the cases here presented. Nevertheless, it appears of value to present these cases with a discussion of the associated kymograms.

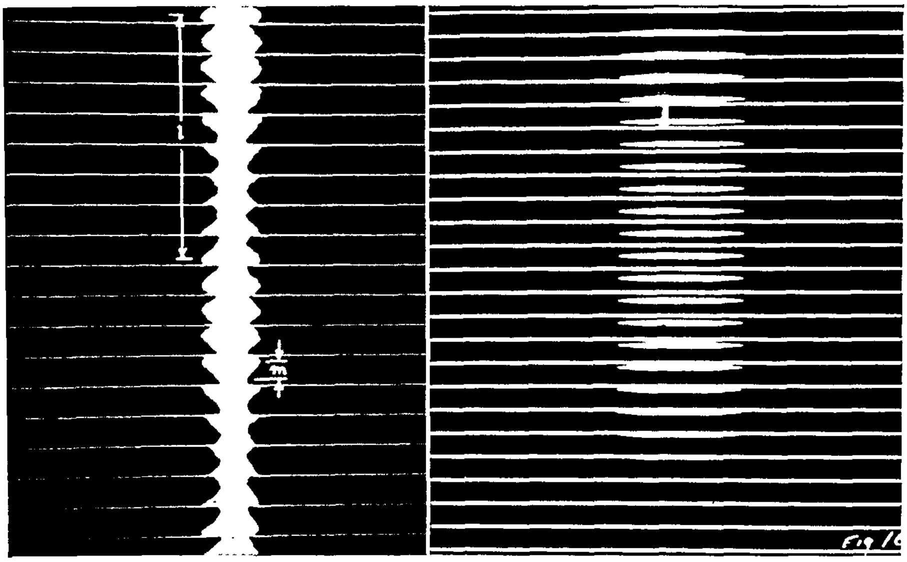


Fig. 15. Fig. 16.

Fig. 15. Peristaltic wave. l is the distance between bands showing same phase. This is the length of the wave. $\frac{m}{v}$ is the time for a half period; the time for the full period is $\frac{2m}{v}$ and the velocity of the peristaltic wave is $\frac{lv}{2m}$ (Case 7).

Fig. 16. Kymogram of a sphere moving uniformly in a direction parallel to the film and perpendicular to the slits.

The consideration of these cases will show the difficulty of concluding from the kymogram as to the actual movement. This situation is characteristic of radiography in general. It is impossible to conclude from a radiograph as to the size and shape of a structure. The radiograph cannot uniquely determine the structure producing it. The kymogram, as well, cannot uniquely determine the movement. In clinical roentgenography, the film is used to determine the structure in the light of anatomic possibilities. In the same way, the kymogram must be used to determine movement and shape in the light of anatomic and physiologic possibilities.

Case 1. A sphere, center fixed in space, but expanding and contracting rhythmically.

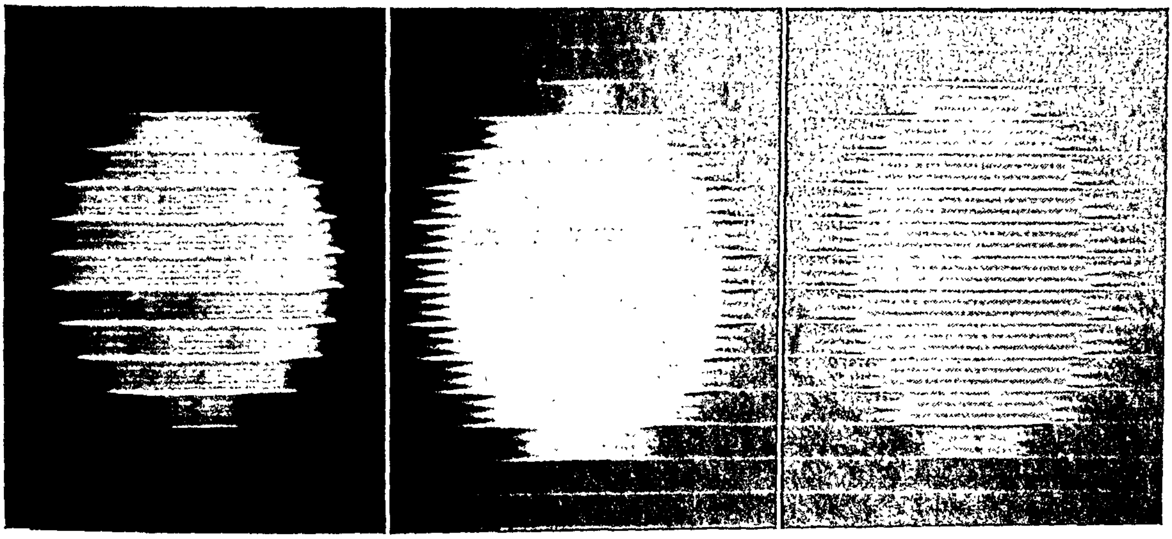
The waves throughout (Fig. 9-*A*), both contour and density, are in phase. The amplitudes of the contour waves show a progressive change along each contour, being smallest in the band approximately at the center of the shadow. The real amplitude is constant over the whole border, and is actually equal to the amplitude of the oscillation (except for correction due to target–object–film projection errors).

Case 2. A rigid sphere oscillating in a direction along the central ray (centric projection).

The shadow in this case expands and

contracts rhythmically as in Case 1. The contour waves (Fig. 9-*B*) are thus all in phase and vary in amplitude as in Case 1. The density waves will also be similar.

result is due to the movement of the entire shadow in a direction parallel to the slits, and without rotation, the waves on one side must be all in phase, while a com-



A *B* *C*

Fig. 17. Kymogram of a disc-shaped object performing rotatory oscillation about a diametral axis parallel to the film and perpendicular to the slits (Case 9). *A*, *B*, and *C* are correlated with *A*, *B*, and *C* of Figure 18.

plete reversal of phase occurs from side to side.

Case 3. A rigid sphere oscillating along a direction perpendicular to the slits, but parallel to the film.

The kymogram (Fig. 10) is divisible by a diameter parallel to the slits into two portions. In each half, the waves of all types are in phase. The waves in one half are completely out of phase with those in the other half. The real amplitude varies from band to band, and evidently is of no great significance.

Case 4. A rigid sphere oscillating along a direction parallel to the slits.

The kymogram (Fig. 11) may be divided by a diameter perpendicular to the slits in two portions. The waves (both contour and density) in each half are in phase, the contour waves all of the same amplitude. The waves of one half are completely out of phase with those of the other half, but of the same amplitude. The real amplitude varies, and has little significance. A similar kymogram is produced no matter what the shape of the structure. Since the

Case 5. A rigid sphere oscillating along a line parallel to the film but at an angle to the slits. This movement may be considered as a combination of Case 3 and Case 4, the movements occurring simultaneously and of relative amplitude depending on the angle.

The kymogram (Fig. 12) shows three distinct regions, divided by lines parallel to the slits. In each of the regions, top and bottom, all the waves are in phase, but all the waves of the bottom are out of phase with those of the top region. In the middle section, the waves are out of phase on each side. The amplitude variations are clearly indicated in the figure.

Case 6. A rigid sphere moving in such a manner as to combine two rhythmic movements with varying relative amplitude, and out of phase. Two harmonic movements combine to produce a harmonic wave of phase dependent on the phase dif-

ference between the two components and their relative amplitudes.

The resulting kymogram in a case of this type must, therefore, show waves of varying phase along a contour. There is a simple mechanical movement, not probable physiologically, which illustrates this case. It is the rotation of a sphere about an axis perpendicular to the film but not passing through the center of the sphere. This is a combination, out of phase, of Cases 3 and 4. The kymogram (Fig. 13) shows variations in phase around the contour, as is to be expected.

Of greater importance, physiologically, are movements corresponding to combinations of Cases 1 and 4, out of phase. Such a movement would be an expansile pulsation combined with a side swing. The results should also show phase differences from band to band.

Another physiologically possible movement, which must show a phase shift, is a combination of an oscillation perpendicular to the slits but parallel to the film with an expansile pulsation out of phase with it. This is a combination of Cases 1 and 3. Figure 14 shows kymograms of this type of movement. This may be the explanation for the frequently observed phase shift along the border of the left ventricle.

This case is important because phase shifts have been thought by many to be due solely to a peristaltic movement.

Case 7. A cylindrical structure disposed with its axis parallel to the film and perpendicular to the slits, traversed by a regular series of peristaltic waves.

All the waves in each band are in phase (Fig. 15). The waves in various bands are out of phase by an amount corresponding to the differing times at which any peristaltic wave reaches the level of the various slits. From this time difference, together with the actual distance between slits, it is possible to calculate the velocity of the peristaltic wave. The frequency of the peristaltic wave is obviously the same as the frequency of the recorded waves. The length of a peristaltic wave is the distance from one band to the next showing the same phase. The velocity is equal to the product of the length by the frequency.

Case 8. An important type of movement is illustrated in the kymogram of Figure 16. The structure in this case was a sphere moving uniformly in a direction parallel to the film and perpendicular to the slits. In each band the shadow occupies a position (either top or bottom of the shadow) corresponding to the time at which the shadow of the sphere entered (bottom of shadow) or left (top of shadow) the slit. The velocity of movement is evidently calculable from the time difference measurable in the kymogram. This case is representative of the movement encountered in an important physiologic process, deglutition.

Case 9. A disc-shaped object oscillating about a long diameter which is parallel to the film and perpendicular to the slits, as an axis.

The kymograms produced in this case are shown in Fig. 17-*A*, *B*, and *C*. The three records were made with the same disc, oscillating with approximately the same amplitude and frequency of oscillation. The film speed was the same in all three. The marked differences in the record are the result of oscillation about different mean positions. The matter is illustrated in Figure 18 for parallel rays. The records were made with divergent rays, which accounts for the deviation from symmetry of the waves on either side. Near the edges the density waves are in phase with the contour waves, while within the shadow they are completely out of phase. The density waves are the result of changing obliquity.

Case 10. A disc-shaped object, distorted into a skewed, screw-like structure, oscillating about a major diameter.

The kymogram (Fig. 19) shows waves of all types (*A*, *B*, and *C* of Fig. 18), since now various parts of the disc have differing mean position. The density waves are again in phase with the contour waves near the edge, but completely out of phase inside the shadow.

A careful measurement of the original

record also shows a phase shift of certain of the homologous peaks, namely, those corresponding to extreme position 2 in Figure 18-*A* and *B*. This shift is another result of the screw-like shape.

This case is noteworthy since it represents a rigid structure performing simple rhythmic movement, yet showing on the kymogram an assortment of frequencies, notched waves, and phase variations.

All of the kymograms illustrating the various cases given are different in some essential respect. Thus, the kymogram would be sufficient to determine to which case of an unknown type of movement it belongs, provided it belongs to one of the enumerated cases. To make such a decision, all the waves on all contours, as well as the density waves, would, in general, be necessary.

In the clinical application of kymography, the situation is in some ways more difficult, in others simpler. The problem is more difficult because it is rarely possible to record waves over the entire contour of structures in the living; nor is it always feasible to record all the density waves. In addition, the physiologic movements and anatomic shapes are not generally of the simple types enumerated. On the other hand, the shapes of structures are usually well known or independently determinable and the movements are, in general, limited to a small number of physiological possibilities. Thus, in spite of the complexity of the problem, valuable conclusions may frequently be reached.

In many applications this deductive method of approach is not as profitable as in the inductive method. The study of large numbers of normal and pathologic cases yields criteria which permit the evaluation of the kymogram in individual cases. Such studies have been made and are now being continued in many laboratories.

It is interesting to compare the possibilities of kymography with two other procedures, fluoroscopy and cineradiography. Prior to the development of the kymographic method, fluoroscopy was the

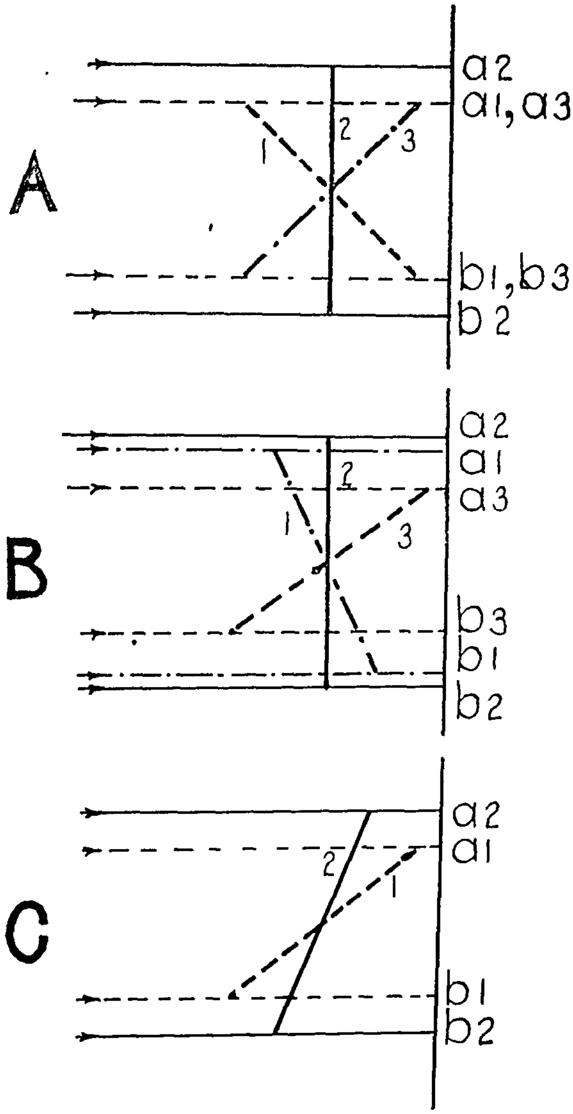


Fig. 18. The genesis of the waves produced by a disc-shaped object oscillating about a diameter disposed parallel to the film and perpendicular to the slits (for parallel rays). The vertical lines at the right represent the film. Points a_1, b_1, a_2, b_2, etc., represent the edge of the shadow produced by the object when in positions 1, 2, etc. Lines with arrows represent rays. *A*. The disc oscillates about a mean position parallel to the film. The diagram shows a section of the disc in the focus–slit plane. The disc oscillates through position 1—2—3—2—1, etc. The shadow expands and contracts for each swing of the disc, so that during a complete oscillation, two peaks are produced on the kymogram. These peaks are of equal amplitude for parallel rays. *B*. Same as *A*, except that mean position is at an angle to film. A similar result is obtained, except that one extreme position of the shadow a_1, b_1, is of different length than the fully contracted shadow, a_3, b_3. *C*. Same as *A* and *B*, except that mean position is at a still greater angle. Here there is only one oscillation of the shadow edge for each oscillation of the disc.

preferred means for the study of the movement of the internal structures. Yet fluoroscopy suffers from precisely the same limitation as kymography. On the fluoroscopic screen only the shadow is visible. Movement of the shadow cannot be correlated with the movement of the structure except in relation to known anatomic and physiologic possibilities.[8] The kymograph (in several projections if desired) yields all the information obtainable from the fluoroscope in a more precise, complete, and permanent form. Thus, for example, a fluoroscopic examination of the heart may show an unusually pronounced pulsation of the aortic shadow. The kymogram will indicate not only the amplitude and form of this pulsation but also its time relationships with the pulsations of the other structures.

The shadow contours at every instant of the cycle are easily determined from the kymogram so that the latter also provides, in a convenient form and by a simple and inexpensive procedure, all the information which could be obtained by means of cineradiography.

Instantaneous Contours.—The shadow at any instant may be constructed from the kymogram. In order that not only shape, but also position, may be properly reproduced, the position of the edges of the shadow at various times must be projected in every band to corresponding standard lines. A convenient standard line in each band is given by its lower edge.

The kymogram (Fig. 20) is that of a rubber balloon filled with water, which, during the exposure, was made to pulsate by the periodic injection and withdrawal of water by means of a syringe. The contours at the times of maximum and minimum diameter in band X were constructed. It is clear how the balloon changed its shape and position with the addition and withdrawal of water.

Figure 21 shows a similar situation with a smaller, stiffer balloon. Note that now the fall in position is not so marked. The situation approximates that of the uniformly expanding or contracting sphere (Case 1, Fig. 9).

Cignolini Method.—In this arrangement the slits are relatively short, and mechani-

[8] The systems of cams and oscillating structures used in the demonstration of fluoroscopy by Levene, at the Fifth International Congress of Radiology, Chicago, 1937 (exhibit No. 44), illustrated this point well.

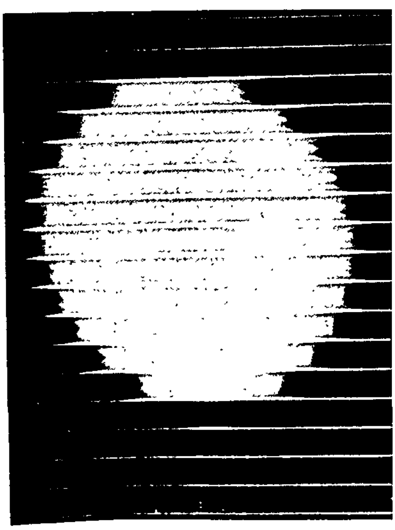


Fig. 19.

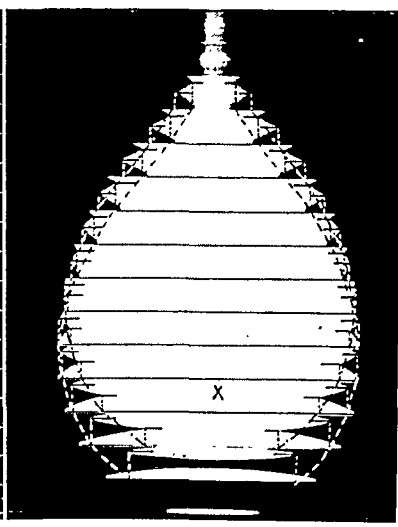


Fig. 20.

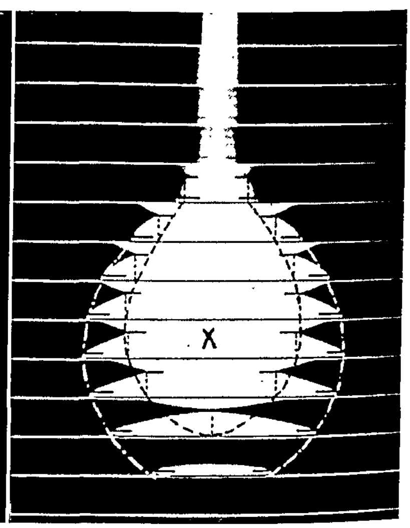


Fig. 21.

Fig. 19. Rotatory oscillation of a skewed disc (screw).
Fig. 20. Kymogram of a pulsating balloon. The instantaneous contours are drawn for the instants of the lateral and mesial peaks in band X. The contours are produced by connecting the projection of the synchronous points in each band on the bottom edge of the band.
Fig. 21. Same as Figure 20, for a smaller and stiffer balloon.

cally arranged so that they may be disposed in a great variety of ways. The slits are all parallel but at various levels. The length of the records of movement (the individual single-slit kymogram) is limited only by the length of film available and the total practicable time of exposure.

In the application of this method by Cignolini, a slit width of 2 mm. was used. The speed of film was 5 cm. per sec., so that the characteristic time was 0.04 second. For the heart, the esthetic requirement is not at all fulfilled. In regions of relatively large obliquity, the unsharpness due to this cause is large. This method has not become very popular, chiefly because of the inconvenience of placing the slits, which must be done under fluoroscopic control. In addition, Cignolini arranged matters so that the entire length of his film (40 cm.) was exposed for each slit. To do this when the slits are at different levels requires 50 per cent more exposure time than that given by l/v. Except for the study of arrhythmias, there appears to be no advantage in the long record.

Morelli Method.—A method using multiple slits, which also has not become very popular, is that developed in South America by Morelli. The slits in that system are arranged radially, and the film (or grid) rotates during the exposure. The extent of rotation is limited to prevent overlapping. Considerations of definition and detail are essentially unchanged since the slit width increases radially so as to maintain a nearly constant characteristic time. The grid described in Morelli's monograph had 18 slits, each approximately 0.5° in angular width, separated by opaque sectors of angular width about 19.5°. The supposed advantage of the method is principally that for the heart the slits are more nearly perpendicular to the shadow border, at least over the ventricle, and hence, *real* and *apparent* amplitudes are nearly alike. Whether this advantage outweighs some of the obvious disadvantages must be determined by experience. Some of these disadvantages are:

(1) Simultaneity in time, and time measurements in general, are more difficult of determination because the time scale depends on distance from the center of rotation.

(2) An error is introduced by any lack of alignment between the radial origin of the slits and the center of rotation.

(3) In the case of the heart, for which the method has been primarily developed, great obliquity errors in vascular shadows must occur if the center of rotation is at the approximate center of the heart.

(4) Standardized technic will be difficult, since it requires special procedures to insure that the center of rotation is always at the same place, even in the same individual.

SUMMARY

(1) The physical principles of slit kymography are discussed, with emphasis upon the factors influencing the accuracy of time measurements. This is discussed in terms of the so-called *characteristic time.*

(2) The condition for records of maximum readability is given and called the *esthetic* relation.

(3) A number of types of movement are studied with the multiple, parallel, and equidistant slits.

(4) The Cignolini and Morelli methods are discussed briefly.

(5) An explanation is offered for the frequently observed phase shift along the cardiac contour. The explanation does not involve peristalsis or screw-like movement, but depends on the assumption that the movement of the heart is a combination of a radial pulsation and an oscillation, these movements being out of phase.

RADIOLOGICAL SOCIETIES IN THE UNITED STATES

Editor's Note.—Will secretaries of societies please co-operate with the Editor by supplying him with information for this section? Please send such information to Leon J. Menville, M.D., 1201 Maison Blanche Bldg., New Orleans, La.

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California Medical Association, Section on Radiology.—*Chairman,* Karl M. Bonoff, M.D., 1930 Wilshire Blvd., Los Angeles; *Secretary,* Carl D. Benninghoven, M.D., 95 S. El Camino Real, San Mateo.

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Illinois State Medical Society, Section on Radiology.—The next meeting will be in Peoria, in May, 1940. The officers are: *Chairman,* Warren W. Furey, M.D., 6844 Oglesby Ave., Chicago; *Secretary,* Harry W. Ackemann, M.D., 321 W. State St., Rockford.

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See New England Roentgen Ray Society.

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RHODE ISLAND

See New England Roentgen Ray Society.

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University of Wisconsin Radiological Conference.—Secretary, E. A. Pohle, M.D., 1300 University Ave., Madison, Wis. Meets every Thursday from 4 to 5 P.M., Room 301, Service Memorial Institute.

EDITORIAL

LEON J. MENVILLE, M.D., *Editor* HOWARD P. DOUB, M.D., *Associate Editor*

I. SETH HIRSCH, M.D.: AN APPRECIATION

"Little call as he may have to instruct others, he wishes nevertheless to open out his heart to such as he either knows or hopes to be of like mind with himself, but who are widely scattered in the world. He wishes to knit anew his connections with his oldest friends, to continue those recently formed, and to win other friends among the rising generation for the remaining course of his life. He wishes to spare the young those circuitous paths, on which he himself had lost his way."

Thus wrote Goethe in his "Introduction to the Propyläen," symbolic of the gateway of the Acropolis of Athens and which offers us an appropriate introduction to the Periclesian work of Dr. I. Seth Hirsch in the temple he has erected to roentgenology. For Goethe's thought touches vitally upon many of the aspects of the life and work of the one this group of papers would memorialize, above all his capacity for knitting his early memories and his many friendships into an integral part of his personality.

Constantly striving forward, with a dynamic curiosity concerning people and things, in spite of difficulties in looking backward, his course through life has shown that consistent bringing of the past to blend with the present and to supply the impulse to mastery of the future.

Living his life in New York City, he has always been surrounded by its tumultous environment. His response to Nature and to people has been vivid, wide, and deep even in his boyhood, and these early stirrings to enter into the heart of things have remained with him throughout the years. The city and its people have a fascination for him which has carried him deeper and deeper into the study of the form and function of the forces molding human destiny as revealed in the internal structure of the human body.

As he himself has told me, one of his earliest memories is of a small churchyard near his home in the city, where two trees so grew as to provide an arching frame and where he would come and gaze for hours, enthralled by the beauty of Nature and also by a curiosity about a slim madonna, in flowing robes, in a niche above the doorway, facing the sky, her hands clasped in prayer. There was a certain furtiveness in this rapture, as it had no counterpart in the strict orthodoxy of his home.

It was but natural that order and form should become second nature to him and that the reading of military campaigns, strategic matching of forces, should have been a passion with him as a boy. He was rarely satisfied with things as they were told to him but was ever experimenting with new methods and contrivances that lay outside of his regular curriculum.

At the College of Physicians and Surgeons, from which he was graduated in 1902, his heroes were Delafield and Hartley, the reporting of the latter's surgical clinics obtaining for him the Harsen Prize. There were also the close contacts with such departing giants as Starr, Bull, Jacobi, and Weir, all noted for their systematic and orderly pedagogic aptitudes as well as their capacity for making new advances in medicine.

Curiosity drove him to the microscope and the bacteriological laboratory and this searching went further into the new discipline of seeing into things just being opened up by the discoveries of Roentgen. Economic needs made of him a general practitioner, fortunately made profitable by a generous patron. He thus went through the arduous, informing, and busy work of general practice with all of its vexations, and fascinations, as he has written it, "Waiting until the cold gray dawn for the head to appear on the perineum, improvising the kitchen furniture and utensils to serve as operating room accessories, witnessing the joys and tragedies of birth and death, and playing the part of the god in the machine in straightening out physical and spiritual entanglements."

As bacteriology offered no means of a livelihood he turned to radiology, entering the field almost as a newcomer who had to construct his own equipment, which temperamentally was "up his alley," as he had already improvised several obstetrical gadgets and it was a natural advance to tubes, tables, holders, and new methods of getting on the inside of things.

Then in 1910, after a Civil Service examination, he was appointed "X-ray Photographer" to Bellevue Hospital. Here again his love for order gave him plenty of scope in rearranging the entire outfit, and for sixteen years endless opportunities for study and for service made his life an arduous, happy, and busy one.

As he says in one of his letters, "My sixteen years there were busy years. Endless opportunities for study, the association with outstanding figures in the medical world, and the contact with students made the years interesting though arduous.

"They were happy years of experimentation and development and association with such men as Norrie, Draper, Stewart, and Norris. These men definitely influenced my attitude and method of approach to scientific problems and the scientific life. They were difficult and troublesome years of continual contention with lay stupidity and ignorance, which assumes the responsibility of directing municipal affairs, bureaucrats, mentally incapable of understanding the continual change in front demanded by advancing medical knowledge and tacitly agreeing to the dictation of the ward heelers and district leaders in hospital matters.

"In spite of continued opposition, I persisted in impudent demands for more space, more equipment, and larger personnel and four years after I entered the hospital, the department was relocated in the place where it still is. It is pleasant to recollect how beautiful was this laboratory, then one of the largest in this country. There was a harmony between appearance and utility in the numerous rooms. Many came to admire its color and orderliness, others the arrangement of its equipment which was then the best which could be purchased or designed, others the technical methods and application to the rapidly expanding field of diagnosis.

"All this was many years ago but time and other corroding factors have since then accomplished their devastating effects."

Now he could turn to writing, and in 1920 his "Principles and Practice of Roentgen Technic," appeared, to be followed in 1925 by his "Principles and Practice of Roentgen Therapy," a pioneer work in English deemed worthy of translation by Holzknecht and Spiegler.

From the beginning he saw beauty, or, to paraphrase Pope, "order as Heaven's first law" and built upon this order his intellectual foundations, giving himself a springboard to his advancements. For his love for getting into the inside of things has enabled him to be an innovator, a discoverer, and a leader, all of which attributes have been appreciated by his confrères. This orderliness has given him the capacity to integrate the teachings of radiology with the basic subjects of anatomy, physiology, and pathology, not to make radiologists of all medical students but physicians for whom the physico-chemical agencies stemming from the discoveries of Roentgen become tools for clinical medical research and therapeutics.

Since 1933 Dr. Hirsch has been Professor of Radiology in the New York University Medical School. Throughout the years there have come from his industry studies characterized by originality, freshness of view point, and a striving for simplification. Particularly noteworthy, however, are his most recent ingenious contributions to the analysis of cardio-dynamic phenomena by permanent roentgen records. Also, he has opened up a new field of kymophono-roentgenography, thus making possible the studying and recording of sound phenomena of the heart and the valvular action responsible for it. He has "hitched" the heart to the x-ray machine in such a manner as to picture this organ in definite phases of its activity.

To his clinical research work he has brought a highly cultivated appreciation of the beauties of Nature. He is a sculptor of note, derived from his sense of beauty of line and its organization, and is no mean artificer in words. In his summer home he has partially realized his dream of a Castle in Spain. It is a place of great beauty and charm, overlooking a valley supreme in its feeling of rest and contentment, symbolic of his inner rapport with Nature, where the "miracle of the Spring to come sharpens his desire for more years of life."

He is still young in years and even younger in striving to bring what was in darkness and confusion to light and order. From Aurelius he early took the precept not to be in love with men's praises. "Behold," he says, "what judges they are in matters which concern even themselves."

I hold it no small privilege to be able to add these few words of appreciation in this plan of friends, associates, colleagues, co-workers, and pupils to mark the outstanding achievements in the field of roentgenology of my friend, I. Seth Hirsch. Long may he live in the body to carry on his work so ably begun!

SMITH ELY JELLIFFE, M.D., Ph.D.

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ANNOUNCEMENTS

REFRESHER POST-GRADUATE SERIES

The Second Annual Refresher Post-graduate Series of the Radiological Society of North America will be offered at the next Annual Meeting, in Atlanta, December 11–15, 1939.

The Executive Committee has set aside Sunday, December 10, afternoon and evening, and from 8 A.M. to 10 A.M. each day of the week during the meeting. The clinics previously held have been abandoned for this year.

Most of the courses offered last year will be repeated and, in addition, a series of basic subjects will be presented by other teachers of national reputation. The courses vary in the total time they occupy. Some of the longer courses will be presented sequentially at the same hour on consecutive days.

The Executive Committee has also ruled that no charge will be made and that members of the Society will be preferentially enrolled. It is the hope of the Committee on Publicity and Education to make the Second Annual Refresher Series basic in its consideration and comprehensive in its scope.

The Committee on Publicity and Education will be pleased to receive comments and helpful suggestions.

MID-SUMMER RADIOLOGICAL CONFERENCE IN THE ROCKY MOUNTAINS

DENVER, COLORADO, JULY 27, 28, 29, 1939

Headquarters, Hotel Shirley-Savoy

Preliminary Announcement: Guest Speakers

Hans A. Jarre, M.D., Detroit, Michigan
James F. Kelly, M.D., Omaha, Nebraska
Sherwood Moore, M.D., St. Louis, Missouri
Bernard H. Nichols, M.D., Cleveland, Ohio
Wendell G. Scott, M.D., St. Louis, Missouri
Paul F. Titterington, M.D., St. Louis, Missouri
Edith H. Quimby, M.S., New York City
Helen Quincy Woodard, M.D., New York City
Symposium on "The Radiation Therapy of Inflammations."
Symposium on "The Radiation Therapy of the Diseases of the Blood and the Blood-forming Organs."
Symposium on Urology
Miscellaneous Subjects—Round Table Discussions.

AMERICAN COLLEGE OF RADIOLOGY

The new officers of the American College of Radiology are as follows: *President*, Fred M. Hodges, M.D., Richmond, Virginia; *Vice-president*, J. C. Dickinson, M.D., Tampa, Florida; *Treasurer*, E. L. Jenkinson, M.D., Chicago, Illinois; *Secretary*, Mac F. Cahal, Chicago, Illinois.

The next annual conference of the College will be held in Chicago at the Palmer House in February, 1940. The next annual meeting of the College will be held in New York City on June 12, 1940.

AMERICAN CONGRESS OF PHYSICAL THERAPY

The eighteenth annual scientific and clinical session of the American Congress of Physical Therapy will be held Sept. 5, 6, 7, 8, 1939, at the Hotel Pennsylvania, New York City. Preceding these sessions the Congress will conduct an intensive instruction seminar in physical therapy for physicians and technicians, August 30, 31, September 1 and 2.

The instruction seminar should prove of unusual interest to physicians and technicians. The clinics which comprise half of the schedule make this course outstanding for its practical

value. As in the past, outstanding clinicians and teachers will participate. Registration is limited to 100 and is by application only. For information concerning seminar and preliminary program of convention proper, address American Congress of Physical Therapy, 30 North Michigan Avenue, Chicago.

COMMUNICATIONS

THE SOLOMON MEMORIAL LIBRARY OF RADIOLOGY

To honor and perpetuate the memory of Dr. Iser Solomon, the eminent French radiologist who recently passed away, Madame Solomon has donated her late husband's radiological library to the Faculty of Medicine of Paris. It will be known as the Solomon Memorial Library of Radiology. In order to make this library complete, she asks that the American radiologists whom Dr. Solomon held in great respect and esteem, contribute their publications which have appeared in the last few years and which because of his illness he was not able to acquire. It is suggested that these contributions bear the author's dedicatory inscription.

The contributions are to be addressed to Madame Iser Solomon, 27, Avenue Trudaine, Paris.

It is hoped that the response to her request will be such that the contributions by American radiologists will occupy a prominent place in this Memorial Library.

AN OPPORTUNITY FOR EXCHANGE

The Editor has received a most interesting letter which opens up such an opportunity for some American radiologist that he is publishing it herewith.

A radiologist located in the Near East is to go on furlough in 1940 for about eight to twelve months. He would like to exchange positions for that length of time with an experienced hospital or university radiologist in the United States. He continues:

"We could exchange houses, cars, and work while keeping our own salaries. My department is not well housed at present, but equipped and staffed satisfactorily. The material of observation is exceedingly interesting, and conditions of work, although quite pleasant, differ entirely from those in large American institutions. Teaching consists of lectures and post-graduate courses. This is a very nice city to live in, in a beautiful country, and the Near East is a fascinating part of the world. There is a fine American and European community; and the people of the country are most pleasant to live with.

"As to myself, you know some of my work; I think it would not be difficult for me to fit in somewhere else. I am 39 years old; after having been in charge of two large teaching departments in Germany, I came here as professor of radiology about five years ago. I do not know much about radium, but am otherwise familiar with both the diagnostic and therapeutic sides of radiology. I have held teaching positions since 1930."

The Editor will forward promptly to the writer of the above letter any inquiries which may be sent to him.

INTERNATIONAL COLLEGE OF SURGEONS

The Fourth Annual Assembly of the International College of Surgeons was held at the Hotel Roosevelt, New York City, May 21–25, 1939. More than 500 representatives of 30 nations participated. Internationally famous surgeons lectured to the assembly on their own latest developments in surgical technics.

The International College of Surgeons is composed of subsidiary national chapters, each being subject to the rules and code of ethics of the medical associations of its particular country. The College itself consists of Fellows and Members, their rank dependent on surgical standing, experience, and age. One of its important functions is to help the younger man; hence associate memberships have been established.

The officers for 1939 are: *International President*, Dr. André Crotti, of Columbus, Ohio; *International President-elect*, Dr. Fred H. Albee, of New York City; *United States Chapter President*, Dr. Frederick M. Douglass, of Toledo, Ohio; *Executive Secretary*, Dr. Edward Frankel, Jr., of New York City; *Editor of the Journal*, Dr. Max Thorek, of Chicago, Illinois.

CONNECTICUT STATE MEDICAL SOCIETY, SECTION ON RADIOLOGY

The annual meeting of the Section on Radiology, Connecticut State Medical Society, was

held May 25, 1939, at Hotel Taft, New Haven, Conn. Dr. Samuel A. Robins, of Boston, Mass., presented a paper on "Recent Radiologic Advance in Urologic and Gynecologic Diagnosis," illustrated with slides. After the scientific meeting the following officers were elected for the ensuing year: *Chairman*, Samuel M. Atkins, M.D., Waterbury, Conn.; *Secretary-Treasurer*, Max Climan, M.D., Hartford, Conn.

FLORIDA RADIOLOGICAL SOCIETY

The Spring Meeting of the Florida Radiological Society was held at the Princess Issena Hotel, Daytona Beach, Florida, on May 1 and 2, 1939. One session was devoted to the study of case histories, illustrated by films; another session to therapeutic problems affecting radiology.

ILLINOIS STATE MEDICAL SOCIETY, SECTION ON RADIOLOGY

The Illinois State Medical Society, Section on Radiology, met in Rockford, in May, and the meeting was most successful. At the annual dinner an election was held, with the following results: *Chairman*, Warren W. Furey, M.D., 6844 Oglesby Ave., Chicago, Illinois; *Secretary*, Harry W. Ackemann, M.D., 321 W. State St., Rockford, Illinois.

The next meeting will be held in Peoria, Illinois, in May, 1940, the exact date to be announced later.

INDIANA ROENTGEN SOCIETY

The annual meeting of the Indiana Roentgen Society was held in Indianapolis on May 21. John D. Camp, M.D., of Rochester, Minn., was a guest for the day and after a dinner in the evening read a paper entitled "Roentgenology of the Calvarium." The following new officers were installed: *President*, Juan Rodriguez, M.D., 2902 Fairfield Ave., Fort Wayne; *President-elect*, H. H. Inlow, M.D., Shelbyville; *Vice-president*, Wemple Dodds, M.D., Crawfordsville; *Secretary-Treasurer*, Clifford C. Taylor, M.D., 23 E. Ohio St., Indianapolis.

KENTUCKY RADIOLOGICAL SOCIETY

A meeting of the radiologists of Kentucky was held at the Brown Hotel in Louisville, April 29, 1939, and the Kentucky Radiological Society was organized. D. B. Harding, M.D., of Lexington, was elected *President;* I. T. Fugate, M.D., of Louisville, *Vice-president*, and Joseph C. Bell, M.D., of Louisville, *Secretary-Treasurer*. Meetings are to be held annually in Louisville, on the third Sunday afternoon in April.

A dinner was served after the business meeting and, following this, Raymond Beeler, M.D., and James N. Collins, M.D., of Indianapolis, spoke to the society concerning the work of the Indiana Roentgen Society.

YOUNG MEN OFFERED FREE SUMMER COURSE ON TRAINING SHIP

The American Nautical Academy, National Training School for Merchant Marine Officers, Washington, D. C., announces that boys and young men between the ages of 11 and 21 years will be allowed to secure practical ship experience on board a training ship of the Academy within the period from June 1 to October 1, 1939.

The young men may remain on board ship for the entire period, or for any shorter time they may wish, but not for less than a month. Students who enter for any period less than the full course will receive instruction only in those subjects being taught while the student is on board ship.

The purpose of the course is: First, as a foundation for those who wish to become officers in the Merchant Marine, and devote their lives to a career in the service; secondly, for those boys and young men who, though not desirous of following the sea, still wish to obtain a general knowledge of ships, and the life afloat.

There is no charge for instruction nor for living quarters on board ship. The only required expense is for meals, which are 49 cents. Three meals are served daily.

There is no tuition charge for any of the courses offered by the Academy, and no obligation for future merchant marine, military or naval service of any kind is incurred by the young men.

The schoolship to which the young men will be assigned is the Training Ship *Marsala*,

a vessel of 2,422 tons, 284 feet long, 45 feet breadth, and built in 1919–20.

On Sundays the cadets will be allowed to attend divine services at the churches of their respective denominations on shore. While on board ship cadets will receive free minor first aid treatment when necessary.

This is the tenth annual summer course offered by the Academy, and will be under the personal supervision of the Captain Commandant of the Academy who will be in command of the vessel.

While on board ship the students will follow the regular daily ship routine, and will be given practical instruction in nautical subjects, including seamanship (ship's work), signaling, rowing, handling and the use of motor boats, pulling boats, life-saving, and naval drills. Many of the duties on board ship are performed by the cadets as part of their training. They will also receive instruction in the use of life buoys, first aid, the compass, log, lead, ground tackle, and the duties of lookouts, as well as the duties of the watch on deck.

Students will join the training ship at Virginia where the vessel will be based at Hampton Roads for the summer training period.

Those completing the summer course with a passing grade will be eligible to apply for a scholarship in the Navigation Course.

Due to the fact that the number of accommodations available is limited, those wishing to take advantage of this opportunity should write at once to the American Nautical Academy, National Training School for Merchant Marine Officers, Washington, D. C.

AUTHOR'S NOTE OF CORRECTION

Dr. William H. Meyer has written the Editor that, in abstracting his article, "The Co-relation of Physical and Clinical Data in Radiation Therapy," published in RADIOLOGY in January, 1939, **32**, 23–45, he has discovered an error which he considers of sufficient importance to request a correction.

On page 37, in the legend for Quantitative Chart No. 11, there is an error in the figures: "(60 r/min.)" should read "(90 r/min.)." The last sentence of two and one-half lines should read as follows:

"Thus, if one changes from (90 r/min.) at 200 kv. and 0.75 mm. Cu filter at 50 cm. S.F.D. to (15 r/min.) at 200 kv. and 2 mm. Cu filter at 70 cm. S.F.D., the total r dose required for a given reaction will increase from 500 r at 90 r/min. to 750 r at 15 r/min."

IN MEMORIAM

BYRON HUBBARD JACKSON, M.D.

Once again Death has stretched forth her hand to claim a valued, beloved, and highly honored member of the Radiological Society of North America in the person of Byron Hubbard Jackson, M.D., of Scranton, Pennsylvania. His illness, of short duration, was known to few, hence his passing on May 16, 1939, came as a great shock to all his friends.

Born in Dallas, Pennsylvania, on Sept. 22, 1873, a son of Mr. and Mrs. John C. Jackson, he spent his boyhood and received his elementary education there. He matriculated at the University of Maryland, from which he was graduated in medicine, in 1898. At the turn of the century, Dr. Jackson began practice with the late Dr. John Price, in Scranton. X-ray development was in its infancy at that time, but as the years went on, Byron H. Jackson was to know fame and gain recognition through the practice of the expanding science of radiology.

In 1933, he served as President of the Radiological Society of North America, during which time he revealed his capacity for able leadership. His acts and influence, official and personal, aided in the development of new and useful devices, in the extension of education in radiology in medical schools, and in the general welfare of the Society. He gained for himself the admiration and devotion of his fellow-members. He was witty, affable, generous, and always manifested a keen interest in the young physician specializing in radiology. He had a large part in the founding of the American Board of Radiology, which was destined to play so important a rôle in raising the standards of education in radiology.

Nor were his honors and activities confined to his specific field nor to our Society. Shortly after becoming established in Scranton, his talents won recognition from his associates and he was elected President of the Lackawanna County Medical Society and later served as its Librarian for several terms. In 1932, English physicians conferred a high honor upon

him by electing him a corresponding honorary member of the Royal Society of London, England. Dr. Jackson was one of six specialists elected to this office and the only one from the United States.

The late BYRON H. JACKSON, M.D.

His work in roentgenology having won Dr. Jackson recognition not only locally, but in the national and even in the international field, many tempting offers came within his grasp to establish himself in a larger field where the opportunities from a purely monetary standpoint would be greater. Dr. Jackson, however, was unwilling to give up the practice and the associations which he had formed in the local community where he made his home. Therefore, he stayed on in Scranton, giving generously of his time to the hospitals of that small city. The physicians who were his associates and those whom he had come to know through his wider contacts in state, national, and international medical societies will alike mourn his passing.

Nor were Dr. Jackson's attainments confined to the study of medicine and his chosen specialty of radiology: he was considered an authority on the Bible, which he studied unceasingly during such leisure as he could command.

In 1928, Dr. Jackson and his wife (*née* Eldridge) made an extensive tour of Europe, among other places, visiting the Radiumhemmet, Stockholm's famed institution for the treatment of cancer by radiation, and the Radium Institute of Paris, where Mme. Curie performed her famous experiments.

Dr. Jackson's professional experiences and connections might well be the envy of any ambitious radiologist. For twenty years he was the chief radiologist at the State Hospital, and served in a similar capacity for many years at the Hahnemann Hospital. At the time of his death he was chief radiologist at the Moses Taylor, West Side, and St. Mary's hospitals. He was a member of his county, state, and national medical societies, also the American College of Physicians, the American Roentgen Ray Society, the American College of Radiology, the Radiological Society of North America, and he was a diplomate of the American Board of Radiology. In all of these, he had held office at one time or another.

To his widow, three daughters, and two sons who survive him, we express our sincere sympathy; they have lost a devoted and beloved husband and father. Our Society has lost an ardent and highly esteemed member, and radiology has lost an able exponent.

ELWOOD E. DOWNS, M.D.

Stricken with an embolism while recuperating from an appendectomy, Elwood E. Downs, M.D., 49 years of age, secretary and treasurer of the Underwood Hospital, of Woodbury, N. J., and widely known radiologist, died suddenly on March 18, 1939. Dr. Downs' recovery following the operation had so far advanced that he had planned to return to his home the next day. He was stricken while sitting in a chair.

Dr. Downs also served as radiologist at Jeanes Hospital, Fox Chase, Pa., and the Salem County Memorial Hospital. He was a recognized authority in this branch of medical practice, and was a Fellow of the American College of Radiology, a past president of the Philadelphia Roentgen-ray Society, a member of the American Roentgen Ray Society, the Radiological Society of North America, and a diplomate of the American Board of Radiology. He was twice president of the Gloucester

County Medical Society and a member of the American Medical Association.

A native of Franklinville, Dr. Downs was graduated from Hahnemann Medical College, after which time he practised for several years at Mullica Hill and Swedesboro, before becoming affiliated with Underwood Hospital. He was elected secretary and treasurer of the hospital in July, 1920. J. Harris Underwood, M.D., head of the hospital, who has been recuperating in Florida following a serious illness, was notified of Dr. Downs' death, and immediately left by train for Woodbury.

Surviving are his wife, Lydia Pratt Downs, and three children: Miss Jane Downs, a student nurse at the Pennsylvania Hospital; Hunter, a pre-medical student at Colgate University, and Richard, ten years old.

Civic honors were accorded Dr. Downs by the city of Woodbury, N. J., where his funeral, the largest for many years, was held. The schools were closed and, by the mayor's proclamation, flags on the city buildings were lowered to half-mast for a period of thirty days.

EDSON S. CUMMINGS, M.D.

(1875–1939)

Dr. Edson S. Cummings, widely known roentgenologist and practising physician of Portland, Maine, for more than twenty years, died there of pneumonia on April 11, 1939. Born in Lewiston, Dec. 7, 1875, Dr. Cummings received his early education in his native city. Following special study at Bowdoin College, he studied at Bowdoin Medical School, being graduated in 1900. First engaged in practice in Lewiston, he was also an attending physician at the Central Maine General Hospital until he entered the medical service when the United States entered the World War. He had since been connected in an advisory capacity with the Lewiston institution. During the World War Dr. Cummings was stationed at Camp Funston, Fort Riley, Kansas, being in charge of the x-ray work at the hospital there, following special work at the Military School of Roentgenology at Kansas City, Mo. He was on duty at Fort Riley until Jan. 8, 1919, when he was honorably discharged, holding the rank of captain at that time.

Returning to Maine, Dr. Cummings soon after located in Portland, where he had been in active practice since. He was for twenty years on the staff of the Maine Eye and Ear Infirmary, in addition to his private practice.

Dr. Cummings was one of the founders of the Medical Research Club, of Lewiston, and took an active part in the County and State Associations. He was a member of the Maine Medical Association, the American Medical Association, and the Radiological Society of North America.

Dr. Cummings' passing is an occasion of grief to his friends in the Society, who extend sincere sympathy to his family.

CHARLES HORACE MAYO, M.D.

The following editorial comment concerning the career of Charles H. Mayo, M.D., is reprinted from the *British Medical Journal* of June 3, 1939. It is such an understanding tribute that it is reprinted here, by courtesy of that Journal.

"The death of Charles Mayo removes one of the greatest figures in surgery, and breaks the most famous partnership of brothers in history. The story of the early days of this wonderful family is common property. How William Worrall Mayo, a young Manchester chemist, emigrated to the United States in 1845, and travelled slowly west in search of opportunity, learning medicine as he went, first as an apprentice in Indiana and later at the infant University of Missouri, then an outpost in hostile country: how he moved with his young family to Minnesota, where he was provost surgeon during the Civil War, and was sent in 1862 with an expedition to quell the Sioux rising, bringing back the skeleton of a chief to teach his sons osteology: how he watched their education in the midst of an ever-growing practice at Rochester: how, helped by his newly graduated elder son, he cared for the victims of a cyclone that swept the town in 1883, and was then asked by the Sisters of the Order of St. Francis to direct the new hospital of St. Mary erected by them in memory of this work: how in 1889 the doctor, now aged 70, took charge of the forty beds, presided over his sons, taught them what he knew of surgery, and handed over the task to them: how the skill of the lads grew and their fame as surgeons spread, so that the work swelled from 751 operations in 1895 to 8,251 in 1910 and 23,628 in 1925: how in 1894 the brothers decided to devote all their earnings, beyond a

yearly sum sufficient to give them reasonable remuneration for their work, to furthering the cause of medical education and the welfare of the sick, and how from this resolve has grown that community of educational foundations, hospitals, parks, and public buildings, that center to which the sick flock for relief and the medical profession for enlightenment, known as the Mayo Clinic.

"In this enterprise, which was unique in its inception and still stands unrivalled in size and scope, the two brothers William and Charles worked for fifty years in complete harmony and unity of purpose, one in their loyalty to the memory of their father and the ideals he set them, one in their devotion to duty and the public welfare. Charles was the younger by four years. He was quiet and simple in his tastes, fond of his home, devoted to his family, delighting in the farm which was attached to his house on the outskirts of Rochester. Like Hunter and Bland Sutton, he had the habits of observation of the naturalist, and sought to apply what he had learned in his work. He was warm-hearted and generous, and became one of the best-loved men in surgery, so that his appearance on a platform was the signal for an ovation that was a tribute to his power of giving and inspiring friendship. He was a forceful and even brilliant speaker when occasion demanded it, but less ready than his brother to enter debate, and his talents were best shown in his genius for clinical discussion and his ready wit, which enabled him to crystallize the results of personal observation in quaint aphorisms that held the fancy and perpetuated his teaching.

"As an operator he was a really brilliant technician, doing work of every kind with a certainty and dexterity that might be equalled by men like Lane or Crile but has probably never been exceeded. When the surgery of the hospital was divided between the brothers, Charles inclined to operations on the head and neck, William to those on the abdomen. Charles led the way in the surgery of the thyroid gland when such work was in its infancy, and earned a reputation for cranial operations, particularly those on the Gasserian ganglion, long before neurosurgery became a separate branch, but whatever he touched he did well. He worked with few instruments, but he could make them do almost anything. His simple outlook can be traced and many of his sayings can be heard in the many theaters where his pupils work to-day.

"But in spite of the characteristics that distinguished them, it is hard to discuss or even to imagine the Mayos apart. It is as the Mayo Brothers that they were known, that they fought their battles and scored their triumphs. At a time when ethics were shaky and commercialism rife, their unquestioned integrity contributed no less than their outstanding surgical skill to establish the reputation of their clinic as a place to which the sick could come for advice and the profession for guidance, happy in the knowledge that neither brother would recommend any course of action or publish any statement without careful thought and firm conviction."

Though Dr. Mayo was not himself a radiologist, he worked so closely with members of our specialty that we may count him as one of ourselves. At the Mayo Clinic, he and his eminent brother established and developed a splendid department of radiology, as all the world knows.

BOOKS RECEIVED

Books received are acknowledged under this heading, and such notice may be regarded as an acknowledgement of the courtesy of the sender. Reviews will be published in the interest of our readers and as space permits.

GASTRO-INTESTINAL DYSFUNCTION. By BARTON ARTHUR RHINEHART, A.B. (Zoology), M.D., Cum Laude (Indiana) A.O.A., Associate Prof. of Roentgenology, University of Arkansas School of Medicine; Consulting Roentgenologist to St. Vincent's Infirmary, Arkansas Baptist Hospital, and Arkansas Children's Hospital; Roentgenologist, Little Rock General Hospital; Member Radiological Society of North America. A volume of 311 pages, with 48 plates. Published by Central Printing Company, Little Rock, Arkansas, 1939. Price not stated.

END-RESULTS IN THE TREATMENT OF GASTRIC CANCER. An Analytical Study and Statistical Survey of Sixty Years of Surgical Treatment. By EDWARD M. LIVINGSTON, B.Sc., M.D., Associate Visiting Surgeon, Bellevue Hospital, New York; Assistant Clinical Professor of Surgery, New York University College of Medicine; formerly Visiting Surgeon, New York City Cancer Institute, and GEORGE T. PACK, B.Sc., M.D., F.A.C.S., Attending Surgeon, Memorial Hospital, New York City; Assistant Professor of Clinical Surgery, the School of Medicine, Yale University, New Haven, and Cornell University Medical College, New York City. With a Foreword by Bowman C.

Crowell, M.D., Associate Director, American College of Surgeons. A volume of 159 pages with numerous charts. Published by Paul B. Hoeber, Inc., New York City, 1939. Price: $3.00. (The material in this volume is reprinted from "The Treatment of Cancer and Allied Diseases," by 142 International Authors, edited by George T. Pack and Edward M. Livingston.)

CANCER HANDBOOK OF THE TUMOR CLINIC, STANFORD UNIVERSITY SCHOOL OF MEDICINE. Edited by ERIC LILJENCRANTZ, M.D., Chief of Tumor Clinic, Stanford University School of Medicine, Consultant in Neoplastic Disease, United States Naval Hospital, Mare Island, and United States Marine Hospital, San Francisco. A volume of 144 pages. Published by the Stanford University Press, Stanford University, California, 1939. Price: $3.00.

MALADIES OSSEUSES (Diseases of Bone). (Recklinghausen's disease, Paget's disease, osseous lipoidosis, multiple myeloma.) By Dr. I. SNAPPER, Professor of the University of Amsterdam. Introduction by Prof. F. De Witte (Gand) and Dr. G. Coryn (Brussels). A volume of 192 pages, with 22 photographic plates. Published by Masson et Cie, Paris, 1939. Price: 330 francs.

BOOK REVIEWS

SILICOSIS AND ASBESTOSIS. By Various Authors. Edited by A. J. Lanza, M.D., Assistant Medical Director, Metropolitan Life Insurance Company; Chairman, Industrial Hygiene Committee of the New York Tuberculosis and Health Association. A volume of 439 pages. Published by Oxford University Press, New York City, 1938. Price: $4.25.

This is a timely contribution concerning a subject that has assumed great importance to industry and diagnostic roentgenology. The Editor is one who has an international reputation for his work in industrial medicine and silicosis in particular. The co-authors are physicians whose contributions to the study of silicosis are well known. To find the opinions and observations of such a group assembled in one textbook is a real medical treat. The contents are divided into seven chapters Chapters 1 and 2, by R. R. Sayers and A. J. Lanza, deal with the history of silicosis and asbestosis and the etiology, symptoms, and diagnosis of silicosis and asbestosis. Chapter 3, by E. P. Pendergrass, is a comprehensive discussion of all the factors pertaining to the roentgen-ray diagnosis. Chapter 4, by S. R. Gloyne, pertains to the pathology of the condition. In Chapter 5, L. O. Gardner presents his well-known observations relating to the experimental pathology of pneumoconiosis. E. L. Middleton, in Chapter 6, presents important observations covering the occupational, preventive, and legislative aspects of silicosis in Great Britain. In Chapter 7, Lanza discusses the public health and economic aspects as they relate to the United States. A comprehensive bibliography for each chapter and a detailed subject index add greatly to the value of the contents.

THIRD SYMPOSIUM ON SILICOSIS. *Official transcript of the Third Silicosis Symposium held* in connection with the Trudeau School of Tuberculosis at Saranac Lake, New York, June 21 to 25, 1937. A volume of 266 pages. Edited and published by B. E. Kuechle, Vice-president and Claims Manager, Employers Mutual Liability Insurance Company, Wausau, Wisconsin, 1937. No price given.

In this book are published papers or abstracts of papers concerning all phases of silicosis, by various physicians and scientists well known in silicosis work. It needs little introduction to those who are interested in this problem and it should be of special interest to roentgenologists. The abstracts of the discussion concerning each paper greatly enhance the value of the work. The general arrangement of subjects is much the same as that followed in previous symposia except that a paper on legislative control and compensation by T. C. Waters has been added. No little praise should go to the publishers whose generosity makes these booklets possible.

KLINIK DER LUNGENASBESTOSE. Klinische, statistische, und röntgenologische Ergebnisse aus Reihenuntersuchungen an Asbestarbeitern über Krankheitsbild und Verlauf der Asbestose (Clinical Aspect of Asbestosis of the Lung. Clinical, Statistical, and Roentgenological Results of Serial Examinations on Workers in Asbestos Factories Regarding the Clinical Picture and Course of Asbestosis). By HANS-WILFRID WEDLER. A monograph of 152 pages, with 36 illustrations. Published by Georg Thieme, Leipzig, 1939. Price: 7.80 RM, bound; 6.50 RM, paper.

The author examined 310 individuals working in asbestos factories and presents ai

analysis of his findings in this monograph. From a historical standpoint it is interesting to note that Plinius is said to have described asbestosis under the name of "slave disease," while the first accurate recent information must be credited to Murray, who in 1899 published the postmortem findings in a worker who had died at the age of 33 after working 10 years in an asbestos factory. The autopsy showed fibrosis of the lungs with asbestosis but no tuberculosis.

Following a brief review of the German literature on the subject the author relates in detail his own experience, arranged under the following headings: Methods of Examination and Discussion of the Clinical Material, *Pathogenesis of Asbestosis, Evaluation of* Anamnestic and Clinical Studies, the Asbestosis Warts, Roentgen Findings, Blood Picture, Histological Connection between Asbestosis and Tuberculosis and Carcinoma, the Dust Hazard in Factories, the Clinical Course of the Disease, Postmortem Examinations, and Medico-legal Comments. The author's statistics show that 77.4 per cent of the examined workers were either free from the disease or had it in its very early stages, 14.8 per cent belonged to Stage 1, 4.8 per cent to Stage 2, and 2.9 per cent to the advanced Stage 3. Data on all cases studied are compiled in a table giving information on age, sex, type of work, cough, sputum, dyspnea, pain, whether or not bronchitis, pleuritis, or emphysema were present, expansion of thorax, including vital capacity, and blood sedimentation. In 174 cases an electrocardiogram was taken. No positive proof could be obtained that any damage to the right heart was caused by the *asbestosis. Six workers died, five were autop*sied, and reports on three are given with microscopic findings. A short bibliography includes references to the international literature. The reproductions of the roentgenograms of a series of selected cases are excellent.

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Benjamin Copleman, M.D., of Perth Amboy, N. J.
Q. B. Coray, M.D., of Salt Lake City, Utah
Lewis G. Jacobs, M.D., of Winona, Minn.
Hans A. Jarre, M.D., of Detroit, Mich.
Eugene T. Leddy, M.D., of Rochester, Minn.
John B. McAneny, M.D., of Madison, Wis.
Max Mass, M.D., of Chicago, Ill.
Antonio Mayoral, M.D., of New Orleans, La.
John M. Miles, M.D., of Lafayette, La.
Lester W. Paul, M.D., of Madison, Wis.
Ernst A. Pohle, M.D., Ph.D., of Madison, Wis.
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CANCER (THERAPY)

Roentgen Therapy of Cancer by the Method of Chaoul. George T. Pack, James S. Gallo, and Boyd F. Wilkinson. Jour. Med. Soc. New Jersey, 36, 15–21, January, 1939.

The authors have treated over 50 patients with various malignant tumors of the skin, including the lip, and a few intra-cavitary cases, by the Chaoul method. They report highly satisfactory results.

In essence, the Chaoul method is described as a modality for delivering high intensity, low voltage (50–60 kv.) radiation to areas accessible to a contact or up to 5 cm. F.S.D. without injury to the deeper structures. The distribution of radiation in the tissues with this method is similar to that obtained with radium surface applicators and less expensive.

The apparatus used by the authors delivers, on contact application, 800 r per minute, 88 r at 3 cm., and 36 r at 5 cm. The heat generated in the tube is dissipated by a constant flow of cold water, making possible direct contact application. The current supplied by the generator is from 4 to 6 ma.

In the treatment of skin carcinomas, the fractional principle is employed, giving from 300 to 400 r units daily until from 6,000 to 9,000 r units have been administered. With epitheliomas about the eye, daily fractions of from 250 to 400 r units were given with total dosages between 3,000 and 8,000 r units with satisfactory results. Recurrent breast nodules were treated with good results.

In carcinoma of the lip, a cross-firing effect is obtained by both external and internal surface application. Fractionated daily doses of from 300 to 400 r units for total dosages of from 4,000 to 6,000 r units to each portal are used. Chaoul reported 90 per cent absolute cure of 20 patients treated in this way. In the intra-oral application, a target-skin distance of from 3 to 5 cm. is used with a filtration of 0.2 mm. of copper. The total dose ranges from 3,000 to 6,000 r units and is given in daily fractions of from 250 to 300 r units. This method is usually combined with external high voltage therapy, usually 200 kilovolts, 60 cm. target-skin distance, filtration of 1 mm. aluminum and 0.5 mm. copper. The total dosage varies from 3,000 to 5,000 r units given in fractions of 300 r units daily.

Carcinoma of the pharynx can be treated by contact radiation when local anesthesia is used. Post-operative marsupialization of carcinoma of the urinary bladder permits accessibility to this type of radiation. The authors have used 2,500 r units every other day for a total dosage of 25,000 r units.

MAX MASS, M.D.

Cancer of the Penis and its Treatment. C. J. Hansson. Acta Radiol., 19, 443–457, November, 1938.

During a 25-year period (1912–1937), 106 cases of cancer of the penis were treated at the Radiumhemmet in Stockholm. The material is divided into three groups, according to the extent of metastatic involvement at the beginning of the treatment: Stage 1, Cases without clinically demonstrable gland metastases; Stage 2, Operable cases with clinically demonstrable metastases, and Stage 3, Inoperable cases with metastases beginning to break through the glandular capsule. Sixty-two per cent of the cases belonged to Stage 1, 22 per cent to Stage 2, and 16 per cent to Stage 3. In most cases the treatment was a combination of radiation and surgery; in only a few cases radiotherapy was employed exclusively.

The methods of treatment and the results are analyzed in all cases in which a five-year follow-up was possible. The percentage of five-year cures amounted to 85 per cent in Stage 1 and to 58 per cent in Stage 2. All cases of Stage 3 succumbed within five years. The author is convinced that a combined radiosurgical approach assures the greatest prospect of success in treatment of cancer of the penis.

ERNST A. SCHMIDT, M.D.

Teleroentgentherapy of Carcinomatous Metastases. L. Mallet. Strahlentherapie, 64, 201, 1939.

The author relates his experience with teleroentgentherapy in the treatment of distant metastases, especially those of the bone. His present technic, in general body exposure, consists of the application of from 25 to 50 r at an F.S.D. of 1.5 meters, 200 kv., 0.5 mm. Cu + 2.0 mm. Al, requiring about one-half an hour for 25 r. This dose is applied at least four times per week, if the general condition of the patient permits as many treatments. The exposure of the thorax, for instance, requires from 30 to 40 single exposures, or a total treatment period of two months, provided that 25 r are given daily. Mallet does not like to exceed from 1,000 to 1,200 r per field per series, but has seen recalcification of bone lesions following doses of from 250 to 300 r per field. Since 1933, he has subjected approximately 600 cases of metastatic carcinoma to teleroentgentherapy. This included bone metastases, advanced primary tumors with glandular involvement, metastases in lungs, pleura, mediastinum, carcinoma of the esophagus, the uterus, the prostate, and some others. Blood examinations at regular intervals are essential, since the white count should not be allowed to drop too low; it is advisable to give transfusions from time to time.

In his series of cases, the author observed some very encouraging remissions. His ideas as to the mode of action of teleroentgentherapy are briefly discussed.

ERNST A. POHLE, M.D., Ph.D.

The Roentgen Treatment of Carcinoma of the Larynx and Hypopharynx. Wendell G. Scott and Sherwood Moore. South. Med. Jour., 32, 144–150, February, 1939.

Intrinsic carcinomas are those of the interior of the laryngeal box, 98 per cent starting in the vocal cords. These can be diagnosed by inspection and biopsy, and must be differentiated from syphilis and tuberculosis. Laryngofissure is the treatment of choice, if the carcinoma is limited to the cord, with a 76 to 82.3 per cent

five-year survival, but generally radical surgery or irradiation is necessary.

Extrinsic cancer of the larynx comprises from 60 to 70 per cent of all laryngeal cancers and may be primarily extrinsic or due to extension of an intrinsic cancer beyond the larynx. Radical surgery is often of questionable value.

If irradiation is employed, for either intrinsic or extrinsic carcinoma, 14 T.E.D. are delivered to the lesion using three portals, 3,000 r units to each lateral port and 2,000 r anteriorly, with daily doses of from 100 to 300 r measured in air. Two hundred kv., 1 mm. copper, and 50 cm. distance are the factors employed.

This same technic is used for cancers of the hypopharynx in which case 11 T.E.D. are delivered to the lesion. The lateral areas are 50 sq. cm. each and the anterior 27 sq. cm.

JOHN M. MILES, M.D.

Extensive Lymphatic Extension of a Cancer of the Breast: Beneficial Effect of Teleroentgen Therapy. P. Ponthus and A. Boijeau. Bull. et mém. Soc. de radiol. méd. de France, **26**, 374–377, May, 1938.

Three years after removal of the right breast (Halstead's operation) the patient, a woman 41 years of age, presented extensive metastases extending as a diffuse infiltration from the right axillary line past the midline, involving the whole of the left breast, both supraclavicular and axillary regions, and the whole of the right rectus muscle. Films of the chest showed extensive thickening of the pleura on the right with a large effusion.

Teleroentgen therapy, with 200 kv., F.S.D. 1 m. 50 cm., 0.8 cm. Cu, and fields covering the whole body, was administered at the rate of 50 r given every fourth day. A total of 950 r was given. The lesions remained stationary but the general state improved remarkably. Five months later a second series of treatments was given, the factors being: 300 kv., F.S.D. 3 m., 0.5 mm. Cu, 20 r per seance given every four days for a total of 120 r. The blood count was not decreased. The general state, however, declined rapidly and the patient died three weeks later.

S. R. BEATTY, M.D.

CONTRAST MEDIA

An Experimental Study on Hysterosalpingography. Part I.—Accumulation Period and Shadow Picture of the Contrast Medium, Morujodol, Injected into the Rabbit Uterine Cavity. S. Hukada. Jap. Jour. Obst. and Gynec., **21**, 316–318, September, 1938.

The author found that opaque material injected into the rabbit uterus did not flow through the uterine tubes into the abdominal cavity as in the human being. In all but a few cases, after about twenty-four hours, it had all been either discharged from the vagina or had been absorbed so completely that a shadow could not be obtained.

However, when the vagina was tied so as to prevent the outward flow of the opaque material, the majority of cases showed clear shadow films for a period of from 10 to 21 days. One case gave a shadow after 13 months.

W. A. WARD, M.D.

An Experimental Study on Hysterosalpingography. Part II.—On the Accumulation Period and Shadow Picture of the Contrast Medium of Iodic Oil Injected into the Pelvio-abdominal Cavity. S. Hukada. Jap. Jour. Obst. and Gynec., **21**, 319, 320, September, 1938.

Since the opaque material injected into the uterine cavity failed to enter the abdominal cavity, the author injected it directly into the pelvio-abdominal cavity and took roentgenograms at proper intervals from one hour to 200 days after injection.

Several hours after injection a shadow film showed the contrast to be still attached to the organs in the abdomen. Later, however, the opaque material accumulated in groups in several places, but never gave a shadow with a certain definite shape. It was sometimes dotted, sometimes lineal, and sometimes reticular.

The time required for complete absorption varied from 40 to 200 days, depending on the kinds and amounts of the media, rabbit constitution, and other conditions.

The author found the absorption of the media to be faster through the abdominal peritoneum than through the endometrium of the uterine cavities.

W. A. WARD, M.D.

Injection of Lipiodol as a Guide in Estimating the Healing of Acute Empyema Cavities. Henry L. Cabitt and Alfred Hurwitz. New England Jour. Med., **220**, 376–379, March 2, 1939.

This is a presentation of four case histories to illustrate the value and advantage of lipiodol instillation into empyema cavities before the drainage tube is removed. A 40 per cent lipiodol solution is introduced by gravity into the cavity and both lateral and postero-anterior films are made of the chest. This procedure will save many embarrassing occasions for the chest surgeon.

J. B. MCANENY, M.D.

THE ELBOW

An Abnormal Calcification of the Medial Surface of the Elbow. Estève. Jour. de radiol. et d'électrol., **22**, 592, 593, December, 1938.

X-ray examination of the right elbow joint of a man aged 25, who had sustained an injury, revealed a large, smooth, somewhat oval, dense shadow the size of a marble, along the internal aspect of the humerus but not connected to it. Since it did not resemble a fracture fragment, the opposite elbow was x-rayed and a corresponding shadow found. The author recalls a

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In the treatment of skin carcinomas, the fractional principle is employed, giving from 300 to 400 r units daily until from 6,000 to 9,000 r units have been administered. With epitheliomas about the eye, daily fractions of from 250 to 400 r units were given with total dosages between 3,000 and 8,000 r units with satisfactory results. Recurrent breast nodules were treated with good results.

In carcinoma of the lip, a cross-firing effect is obtained by both external and internal surface application. Fractionated daily doses of from 300 to 400 r units for total dosages of from 4,000 to 6,000 r units to each portal are used. Chaoul reported 90 per cent absolute cure of 20 patients treated in this way. In the intra-oral application, a target-skin distance of from 3 to 5 cm. is used with a filtration of 0.2 mm. of copper. The total dose ranges from 3,000 to 6,000 r units and is given in daily fractions of from 250 to 300 r units. This method is usually combined with external high voltage therapy, usually 200 kilovolts, 60 cm. target-skin distance, filtration of 1 mm. aluminum and 0.5 mm. copper. The total dosage varies from 3,000 to 5,000 r units given in fractions of 300 r units daily.

Carcinoma of the pharynx can be treated by contact radiation when local anesthesia is used. Post-operative marsupialization of carcinoma of the urinary bladder permits accessibility to this type of radiation. The authors have used 2,500 r units every other day for a total dosage of 25,000 r units.

MAX MASS, M.D.

Cancer of the Penis and its Treatment. C. J. Hansson. Acta Radiol., 19, 443–457, November, 1938.

During a 25-year period (1912–1937), 106 cases of cancer of the penis were treated at the Radiumhemmet in Stockholm. The material is divided into three groups, according to the extent of metastatic involvement at the beginning of the treatment: Stage 1, Cases without clinically demonstrable gland metastases; Stage 2, Operable cases with clinically demonstrable metastases, and Stage 3, Inoperable cases with metastases beginning to break through the glandular capsule. Sixty-two per cent of the cases belonged to Stage 1, 22 per cent to Stage 2, and 16 per cent to Stage 3. In most cases the treatment was a combination of radiation and surgery; in only a few cases radiotherapy was employed exclusively.

The methods of treatment and the results are analyzed in all cases in which a five-year follow-up was possible. The percentage of five-year cures amounted to 85 per cent in Stage 1 and to 58 per cent in Stage 2. All cases of Stage 3 succumbed within five years. The author is convinced that a combined radiosurgical approach assures the greatest prospect of success in treatment of cancer of the penis.

ERNST A. SCHMIDT, M.D.

Teleroentgentherapy of Carcinomatous Metastases. L. Mallet. Strahlentherapie, **64**, 201, 1939.

The author relates his experience with teleroentgentherapy in the treatment of distant metastases, especially those of the bone. His present technic, in general body exposure, consists of the application of from 25 to 50 r at an F.S.D. of 1.5 meters, 200 kv., 0.5 mm. Cu + 2.0 mm. Al, requiring about one-half an hour for 25 r. This dose is applied at least four times per week, if the general condition of the patient permits as many treatments. The exposure of the thorax, for instance, requires from 30 to 40 single exposures, or a total treatment period of two months, provided that 25 r are given daily. Mallet does not like to exceed from 1,000 to 1,200 r per field per series, but has seen recalcification of bone lesions following doses of from 250 to 300 r per field. Since 1933, he has subjected approximately 600 cases of metastatic carcinoma to teleroentgentherapy. This included bone metastases, advanced primary tumors with glandular involvement, metastases in lungs, pleura, mediastinum, carcinoma of the esophagus, the uterus, the prostate, and some others. Blood examinations at regular intervals are essential, since the white count should not be allowed to drop too low; it is advisable to give transfusions from time to time.

In his series of cases, the author observed some very encouraging remissions. His ideas as to the mode of action of teleroentgentherapy are briefly discussed.

ERNST A. POHLE, M.D., Ph.D.

The Roentgen Treatment of Carcinoma of the Larynx and Hypopharynx. Wendell G. Scott and Sherwood Moore. South. Med. Jour., **32**, 144–150, February, 1939.

Intrinsic carcinomas are those of the interior of the laryngeal box, 98 per cent starting in the vocal cords. These can be diagnosed by inspection and biopsy, and must be differentiated from syphilis and tuberculosis. Laryngofissure is the treatment of choice, if the carcinoma is limited to the cord, with a 76 to 82.3 per cent

phatic spread seems to be rare. While the prognosis is bad, palliative treatment by means of x-rays or radium should be applied. Since there is a possibility that biopsy favors the spread of the primary tumor, it is recommended that the endotherm method be used for procuring a specimen for histologic examination.

ERNST A. POHLE, M.D., Ph.D.

Congenital Atresia of the Esophagus. J. W. D. Bull. British Med. Jour., 2, 983-985, Nov. 12, 1938.

The disease described is of interest in that, according to the author, it occurs more frequently than is generally believed and may, therefore, confront any diagnostician. The pathology consists mainly of a tracheobronchial fistula with an atresia just below.

The situation becomes apparent under the fluoroscope with the ingestion of barium and is verified as it progresses, with the accompanying lack of gastrointestinal function. Few of these patients live more than a week. Various surgical procedures have been suggested but the fact that the patient is nearly always the victim of other congenital lesions makes the outlook rather hopeless.

Q. B. CORAY, M.D.

Rupture of the Esophagus with Spontaneous Recovery of the Patient. Samuel Iglauer. Ann. Otol., Rhinol., and Laryngol., 47, 1083-1088, December, 1938.

The author reports a case of rupture of the esophagus following attempted retrograde dilatation in which the patient made a spontaneous recovery. A gastrostomy had been done previously because of high-grade esophageal obstruction. After the attempted dilatation the patient had a severe reaction. X-ray examination revealed the tip of the gastrostomy tube in the posterior mediastinum and lipiodol instilled into it entered the left bronchus. The tube was left in place and this may have served for drainage of the purulent mediastinitis which developed, since the patient made a recovery without further surgical intervention.

LESTER W. PAUL, M.D.

A Case of Diverticulum of the Esophagus. M. Estève. Jour. de radiol. et d'électrol., 22, 505, 506, October, 1938.

The author presents a case of diverticulum of the esophagus in a woman 60 years of age, complaining of the usual symptoms of this condition. X-ray examination in the oblique position showed the typical appearance of an olive-sized sac originating from the posterior wall of the esophagus at the level of the seventh cervical vertebra. The superior border was horizontal and the inferior border was convex so that it could easily be differentiated from carcinoma. The appearance was characteristic of a pulsion diverticulum and, no doubt, of congenital origin.

There is no tendency toward spontaneous healing. However, most surgeons (probably not American ones) are opposed to surgical intervention which, they feel, usually makes the condition worse. They, therefore, recommend frequent buccal lavage with antiseptic solutions and careful and thorough mastication.

Two illustrations show the condition clearly.

J. SAGEL, M.D.

FOREIGN BODIES

An Apparatus for the Localization of Foreign Bodies. P. Cottenot. Bull. et mém. Soc. de Radiol. Méd. de France, 8, 88, 89, February, 1938.

The author has designed an apparatus which is used in conjunction with an ordinary viewing box to form a simple seriescope using but two films. By using two films taken at a given focal-film distance and a predetermined shift, it is possible to localize foreign bodies accurately and conveniently by merely reading the graduations of a scale.

S. R. BEATTY, M.D.

Radioscopic Localization of Foreign Bodies: System of Two Parallelograms. Mazérès. Bull. et mém. Soc. de radiol. méd. de France, 26, 426-429, June, 1938.

The author describes a simple non-mathematical procedure for localizing foreign bodies. With the patient lying on the table under the screen, the tube is moved until the foreign body and its image are in the central ray and a marker is then placed on the skin at a point coinciding with the shadow of the foreign body. The tube is then rotated through an angle x, which may be any convenient angle, and moved in the direction opposite to the angle of rotation until the foreign body lies again in the principal ray. Next a cross is marked on the screen at the shadow of the foreign body, and the tube displaced further until the marker lies in the central ray. The screen is then raised vertically until the shadow of the marker and the cross coincide. The distance that the screen is raised is the distance of the foreign body below the skin marker. Sources of error are discussed and a correction factor for obliquity of the screen is derived.

S. R. BEATTY, M.D.

FRACTURES

Double Fracture of the Ribs from Coughing. Olinto Parenti. Arch. di Radiol., 14, 318-323, 1938.

The author's patient, who had bilateral pulmonary tuberculosis, fractured two ribs by coughing, a rather unusual event.

E. T. LEDDY, M.D.

Fracture of the Neck of the Femur: A Personal Experience. John C. Nicholson. British Med. Jour., 2, 464-466, Aug. 27, 1938.

This article is a critical analysis of the more common methods of treating fracture of the neck of the femur and it impresses one as being doubly valuable in that the author is also the patient. Due probably to the whims of "whatever gods may be," Nicholson was

similar case in which, however, the opposite elbow had not been x-rayed.

In the differential diagnosis, fracture was excluded. A supernumerary bone was considered but it had never been seen nor described. A trochlear nucleus which had never fused seemed unlikely. Cartilaginous "stones" are generally more numerous. The appearance does not suggest osteochondritis dissecans.

A similar case has been reported by Kohler, who recounts two or three other cases of his associates. He does not consider trauma the cause. In one case histologic examination showed the structure to be cartilaginous without any ossification.

The author favors a congenital origin (supernumerary bone) or a developmental anomaly of the trochlear tubercle (absence of fusion). He suggests more frequent examination of the opposite elbow for comparison, even when the injury is in an adult, because of the medico-legal aspect.

J. Sagel, M.D.

ENCEPHALOGRAPHY

The Diagnostic Evaluation of Subtentorial Accumulation of Air. L. Haas. Fortschr. a. d. Geb. d. Röntgenstrahlen, 58, 18–33, 1938.

In 102 pneumoencephalographic examinations, air was found 24 times in subtentorial spaces—21 times with cisternal, three times with lumbar injection. This occurrence, as such, is not attributed to any pathognomonic significance. The normal appearance of these subtentorial spaces is described and illustrated. They present themselves better in views obtained when the patient is in a sitting position than when he is lying down. Caution is necessary to avoid confusion with a posterior or inferior horn of the lateral ventricle and with a deep sinus transversus.

At times, subtentorial air adds materially to diagnostic recognition: persistent monolateral filling of this space is pathologic, indicating increased pressure on the non-filled space or reduction of the tissue mass surrounded by the air. Any deviation of the air-band, or encroachment on it, can be of diagnostic significance, especially when the decision between supra- and infra-tentorial tumor has to be made. It has been found, futhermore, that air is present in subtentorial spaces most frequently in cases of posterior occlusion of the normal channels.

H. A. Jarre, M.D.

Cerebral Pneumography in Childhood. A. E. Childe. Canadian Med. Assn. Jour., 39, 552–555, December, 1938.

Cerebral pneumography includes procedures commonly known as encephalography and ventriculography.

In encephalography spinal fluid is withdrawn by lumbar puncture and replaced with gas. In this manner the ventricular system and also the subarachnoid space are outlined. This method of examination is safe in patients who have no increased intracranial pressure. One of the most common indications for encephalography in childhood is suspected feeble-mindedness or backwardness. Many of the patients present varying degrees of diffuse cerebral atrophy as evidenced by large ventricles which may or may not be symmetrical. In the case of a subdural or extradural hemorrhage, the ventricles shift away from the expanding lesion. When atrophy is present, however, the ventricles enlarge and tend to shift toward the atrophic lesion.

In ventriculography gas is introduced directly into the lateral ventricles. This is the method of choice in patients with increased intracranial pressure. Several different types of expanding lesions occur in childhood, *i.e.*, pontine neoplasms that often cause posterior displacement of the aqueduct of Sylvius and the fourth ventricle; abscesses in the temporal region following infections of the middle ear, and in the frontal lobe, occasionally, as a result of infection of the frontal sinuses, and metastatic abscesses from such conditions as bronchiectasis.

Encephalograms and ventriculograms can be intelligently interpreted only in conjunction with other findings.

M. L. Connelly, M.D.

THE ESOPHAGUS

Metastases in the Esophagus. E. Proske. Strahlentherapie, 64, 227, 1939.

Since the introduction of the protracted fractional dose method, a considerable percentage of tumors in the pharynx and larynx have been treated successfully by irradiation. A survey of this material in the Roentgen Institute at the University of Zurich revealed the fact that some of these cases died later from secondary tumors in the esophagus. They occur chiefly in patients with primary tumors of the mesopharynx, as well as the posterior hypopharynx wall. No secondary tumors of the esophagus were seen in patients with a primary malignancy of the intrinsic larynx and the epipharynx, while the occurrence was rare in patients with primary carcinoma of the mouth. In a series of 382 cases of tumors of the meso- and hypopharynx, 21 secondary neoplasms of the esophagus were observed. One was discovered before the diagnosis of a primary mesopharynx neoplasm was made. Three were seen when starting treatment of a tumor of the pharynx and all others apparently did not develop until after treatment of the primary growth had been completed. The frequency of the occurrence is estimated at about 11 per cent. No secondary neoplasms of the esophagus were seen in patients with sarcoma; it was limited to those with a primary carcinoma. In nine cases the histologic structures of primary and secondary growth were the same; in one case it differed. No relationship was found between the size of the primary tumor or the regional metastases and the occurrence of the secondary neoplasm in the esophagus. The most frequent site of the esophageal metastasis was the middle and lower third. In the majority of the cases the secondary growth occurred by implantation; lym-

forced to bear up under all four of the most generally accepted therapeutic methods, namely, sandbags, weight extension, Whitman plaster, and finally the Smith Peterson nail fixation. He comments as follows:

Sandbags.—Most painful and inefficient. Extension should be instituted at once. Nothing to recommend the old idea of rest for 24 hours.

Weight Extension.—The Steinman pin through the lower femur is most effective. Adhesive extension is most uncomfortable and leaves the skin sore. Kirschner wire through the tibia is less bothersome but causes stiffness of the knee joint.

Plaster of Paris.—The most uncomfortable, debilitating, expensive, awkward, and generally damnable method in use. The author states that he now employs the Whitman cast with his patients only as a last resort.

Radiologically Controlled Nailing.—Four weeks after this process the patient went home on crutches and could drive his own car. Seven weeks later he was again able to operate.

In conclusion, the author comments on the various arguments against the Smith Peterson nail and states that these are greatly outbalanced by the increased comfort and speed of recovery of the patient.

Q. B. Coray, M.D.

Presentation of Radiographs. R. Guérin. Bull. et mém. Soc. de Radiol. méd. de France, **26,** 290–292, April, 1938.

A presentation of roentgenographs of a case of congenital fusion of the second and third lumbar vertebral bodies, a case of double fracture of the head and neck of the femur, and a case of fracture through the acetabulum.

S. R. Beatty, M.D.

GALL BLADDER (NORMAL AND PATHOLOGIC)

The Effect of Benzedrine, Benzedrine and Atropine, and Atropine on the Gall Bladder. Purcell G. Schube, A. Myerson, and R. Lambert. Am. Jour. Med. Sci., **197,** 57–61, January, 1939.

The physiologic actions of benzedrine sulphate are due to stimulation of the sympathetic division of the autonomic nervous system, and are demonstrated in the gastro-intestinal tract by an increase in acidity and pepsinogen of the gastric juices, and a decrease in the tonus of the entire tract. The observation that paralysis of the parasympathetic system by atropine enhanced the effect of benzedrine, stimulated this investigation of the effects of these drugs, separately and in combination, on the gall bladder.

After a control cholecystographic examination, the procedure was repeated by administering each of these drugs in a new series, after which the gall bladder was again fully visualized.

The size and emptying of the gall bladder were affected very little by benzedrine alone. When atropine and benzedrine were used together, the gall bladder increased in size in a few cases. There was, however, a definite delay in the emptying, after a fatty meal. With the use of atropine alone, it was found that although no appreciable change in size took place, a very definite delay in emptying occurred after the fatty meal.

The emptying mechanism of the gall bladder is considered by Ivy to be due to direct physical or chemical stimulation of the gall-bladder wall, or by indirect stimulation through the autonomic nervous system. It appears that, generally, benzedrine delays emptying of the gall bladder only after a long period has elapsed following the administration of the drug, and that sympathetic stimulation, if it is effective, occurs only after some time. Apparently, a sympathetic stimulant and a parasympathetic paralysant together are effective in delaying gall-bladder emptying, but the effect is more marked with the parasympathetic paralysant, atropine, alone, while the sympathetic stimulant used by itself is ineffective.

Benjamin Copleman, M.D.

Physiological Investigation of the Gall Bladder. Rosario Impallomeni. Radiol. Med., **25,** 583–596, July, 1938.

The author makes a thorough, searching investigation of the appearance of the gall-bladder shadow, its size and density. At different times he uses different methods and injects various substances intravenously, mixed with, or simultaneously with, the tetraiodophenolphthalein solution. These researches have yielded the rather interesting conclusion that when it is possible to get a rapid visualization of the gall bladder by Graham's method, this appears at the second hour, casting a small and light shadow that increases in size and opacity hourly. This observation makes one doubt the assertion that at the beginning of a cholecystographic study the gall bladder is filled and distended with bile, and leads one to think that in the method of rapid visualization of the gall bladder, based on the principle of emptying this viscus at the beginning of the test, if this is rapidly visualized it is due to a mechanism different from that following a provocative emptying.

By intravenous injection of biliary salts mixed with the tetraiodo, a more physiologic cholecystographic method is available, inasmuch as the secretion of bile is stimulated by a method somewhat similar to that excited by the normal absorption of bile from the intestine. Using this method, in normal subjects, the visualization of the gall bladder begins in 15 minutes and at the end of one hour in most of the cases, it has reached its maximum size. During the second hour, the vesicular shadow becomes intensely opaque, corresponding in size and density to that seen during the ninth or tenth hour, when using Graham's method.

Bronner's method, when used in normal subjects, shows the same efficacy as Graham's, after the second hour.

In pathological cases, when the vesicular shadow is not clear enough at the second hour, it becomes necessary to take other films during the fourth or fifth hour. One

can, thereby, bring out a slow-filling gall bladder or slow concentration of the intravesicular contents showing faulty visualization.

The last series, studied after adding to the usual dose of tetraiodo from three to four c.c. of "aminoacidi," have shown the importance of the alimentary stimulus in bile secretion during the rapid visualization of the gall bladder. With this method, an earlier visualization of the gall bladder is obtained—slow, but nevertheless faster than when the biliary salts are used.

It seems clear, therefore, that when either bile salts and aminoacids are injected simultaneously with the tetraiodo a more rapid visualization of the gall bladder is obtained than when either Bronner's or Graham's method is followed. It seems clear, also, that with these methods investigation of the power of absorption of the vesicular wall becomes roentgenologically possible.

The article is excellent but difficult to abstract. For those especially interested in the subject the reading of the article is recommended.

ANTONIO MAYORAL, M.D.

Oral Cholecystography with Divided Doses. Pawel Adamowicz. Polski Przegl. Radiol., **13**, 123–137, 1938.

The author's technic consists in the administration of four grams of the dye in the afternoon preceding the morning of the x-ray examination. In case of an unsatisfactory gall-bladder shadow, a supplementary dose of two grams of dye is given following this first x-ray examination, and further roentgenograms are taken the next afternoon and succeeding forenoon. If necessary, these examinations are complemented by fatty meals.

In the author's opinion, the radiographic results obtained by his method are equal or even superior to those achieved by means of the intravenous procedure.

ERNST A. SCHMIDT, M.D.

GASTRO-INTESTINAL TRACT (DIAGNOSIS)

Acute Dilatation of the Stomach and Arteriomesenteric Stenosis of the Duodenum. Emil Meisels. Polski Przegl. Radiol., **13**, 103–121, 1938.

Basing his conclusions on the x-ray diagnosis and clinical observation of three cases, the author discusses the principal features and etiologic factors in acute dilatation of the stomach and in arterio-mesenteric stenosis of the duodenum. He believes that, in spite of great differences in the clinical course, the two diseases should be considered a nosologic entity. To support this theory, the following common characteristics are adduced: (1) Presence of simultaneous dilatation of duodenum and stomach in cases of acute gastroplegia, and of gastric dilatation in many cases of arterio-mesenteric stenosis of the duodenum; (2) Frequent extent of the duodenal dilatation to the middle of the third portion to a point where the duodenal wall is crossed by the mesenteric pedicle; (3) Sharp and distinct delineation from the small intestine below (which is narrow and almost empty), and (4) In the majority of cases, absence of lesions which might explain the mechanical pathogenesis of the stenosis.

Concerning the mechanism of the obstruction, different theories are dealt with in detail: the original Rokitansky-Albrecht explanation of direct compression by the mesenteric artery, the later explanation of American and French authors (Codman, Bloodgood, Duval, and others) emphasizing diminution of the arterio-aortic angle due to traction and ptosis, and, finally, the theory of functional neuro-muscular disturbances, either due to reflex action or to neuropathic hypersensibility toward certain agents (*e.g.*, toxic agents after narcosis).

The author calls attention to analogies with the idiopathic dilatation of the esophagus which must be considered the result of disturbances in the neuromuscular system regulating deglutition.

ERNST A. SCHMIDT, M.D.

The Diagnostic Value of a Plain Roentgen Study of the Abdomen. Heinrich Müller. München. med. Wchnschr., **85**, 1999–2001, Dec. 23, 1938.

The author routinely makes a plain study of the chest and abdomen before every gastro-intestinal series and barium enema. He points out that much valuable information may thus be gained. Cases of kidney stone, gallstone, calcified kidney, and abdominal cystoma are reported, and the diagnoses of enlargement of the gall bladder, mesenteric cyst, traumatic pancreatic cyst, abscess, perforated ulcer, ileus, encapsulated effusion, liver abscess, and acute pancreatic necrosis are briefly discussed. It is felt that this procedure is of great diagnostic worth.

LEWIS G. JACOBS, M.D.

Chronic Gastritis. Serse Zanetti and G. Guerreri D'Antona. Radiol. Med., **25**, 945–966, November, 1938.

This is a very complete article. The authors review the different historical epochs in diagnosis, beginning with the early work of Morgagni who, in the eighteenth century demonstrated the presence of ulcerations in the mucosa. This was followed, in rapid succession, by the era of chemical examination of gastric juice, of Ewald and Boas; anatomical-clinical of Hayem; surgical of the Mayos, Robson, and of Moynihan; then the radiological era, and now the new and relatively recent use of the flexible gastroscope. Special emphasis is given to the work of Forssell who has so conclusively demonstrated the autonomous power of motility of the mucosa of the gastro-intestinal tract, and its ability to assume distinct patterns to conform with the necessities of digestion.

The work is based on nearly six hundred cases of recovered ulcer patients. On these, 250 resections were done, and the conclusions are derived from the clinical, pathologic, and radiologic studies of this vast number of cases. The authors call attention to the lack of

pathognomonic symptoms in gastritis, and to the fact that gastritis and ulcer are always found to be co-existent. Although this is true, they believe it unwise to affirm that all the symptoms of one condition are due to the presence of the other. After studying the resected specimens, however, one could not feel disposed to make an absolute denial that ulcer symptoms, whether gastric or duodenal, are due to the co-existing gastritis. When, however, dealing with those cases presenting atypical symptomatology, these may be due to allied lesions. On the other hand, when the patient presents the classical symptoms of ulcer it is always chronic (ulcers of Cruveilhier), the mucosal lesions showing a marked tendency toward chronicity and atrophy. The authors conclude by stating that the more marked or the more advanced the gastritis, the more difficult the clinical diagnosis of ulcer, whether gastric or duodenal.

The value of roentgenologic examination of the stomach, when done by small feedings, needs no emphasis and these authors plead for a closer co-operation between the surgeon and the radiologist in studying each other's work, especially the latter, who should make a careful inspection of all resected specimens before they are fixed, in order to help him conceive an exact picture of the living organ.

In making the radiological examination, the following absolute rules should be followed: a complete emptying of the stomach and perfect roentgenograms. To obtain these results, a technic rapid enough to stop motion should be used. A clean colon and well-aimed rays are essential in obtaining good patterns of the mucosa.

Acute gastritis presenting no characteristic mucosal alterations is not suitable for x-ray diagnosis; the references herein contained are, therefore, concerning chronic gastritis.

The radiologic differential diagnosis of chronic gastritis is based on the anatomic-pathologic changes taking place in the mucosa. They are classified as atrophic or hypertrophic, both types being not infrequently co-existent.

Hypertrophic gastritis is recognized by the increase in size of the rugæ, these being decreased in number, but increased in length, while their elasticity is greatly reduced. They follow a very irregular course, being straight or serpentigenous. In advanced cases, the mucosal pattern may become completely disorganized. When the site of the lesion is the fundus of the stomach, the diagnosis is extremely difficult and at times impossible. The hypertrophy of the rugæ is maintained by an abnormal serous absorption by the gastric wall, the action being especially evident in the submucosa.

The atrophic type is characterized by less prominent rugæ which follow an almost normal course. At times, however, there is a complete disappearance of mucosal pattern, the lesion being generally limited in distribution, except in cases of chemical gastritis. The gastric region most commonly affected is the fundus, but based on roentgenologic investigation, it must be said that atrophic gastritis presents a queer distribution. Nevertheless, caution should be exercised by the roentgenologist in diagnosing this type of lesion, as there are many other conditions that can simulate the mucosal relief. When, however, both types, as often happens, are found in the same stomach, the mucosal pattern assumes a characteristic radiologic picture. To the long serpentigenous and rigid rugæ, seen in polypoid gastritis, are associated almost imperceptible rugæ, or, frequently, there is complete absence of mucosal folds, the marking seen in the film of the gastric region simulating the color streaks seen in a piece of polished marble, or they may be a uniformly opaque blotch, the opacity at the edges blending gradually with the surrounding shadows.

This description of the main radiological signs of gastritis is followed in this article by timely and useful observations on ulcerative gastritis and finishes with the following sentence: "We repeat the necessity of exercising great care in making a diagnosis of ulcerative gastritis: this should be made only after very accurate and painstaking examinations."

In the opinion of the authors, the radiologic examination should not be limited to diagnosis as it also has a great prognostic value. When the mucosa is greatly inflamed, the inflammation is also extensive and contra-indicates surgical intervention, as greatly inflamed tissue offers bad post-operative risk. A well and carefully conducted radiologic investigation, which shows an exact picture of the internal relief of the stomach, will inform the surgeon of the condition of the mucosa and also assist him in deciding for or against intervention.

Antonio Mayoral, M.D.

ANNOUNCEMENT

THE TWENTY-FIFTH ANNUAL MEETING

of

THE RADIOLOGICAL SOCIETY OF NORTH AMERICA

WILL BE HELD IN

ATLANTA, GEORGIA

DECEMBER 11th, 12th, 13th, 14th and 15th

RESERVE THESE DATES NOW

Headquarters, ATLANTA BILTMORE HOTEL

EXECUTIVE SESSIONS

SCIENTIFIC SESSIONS

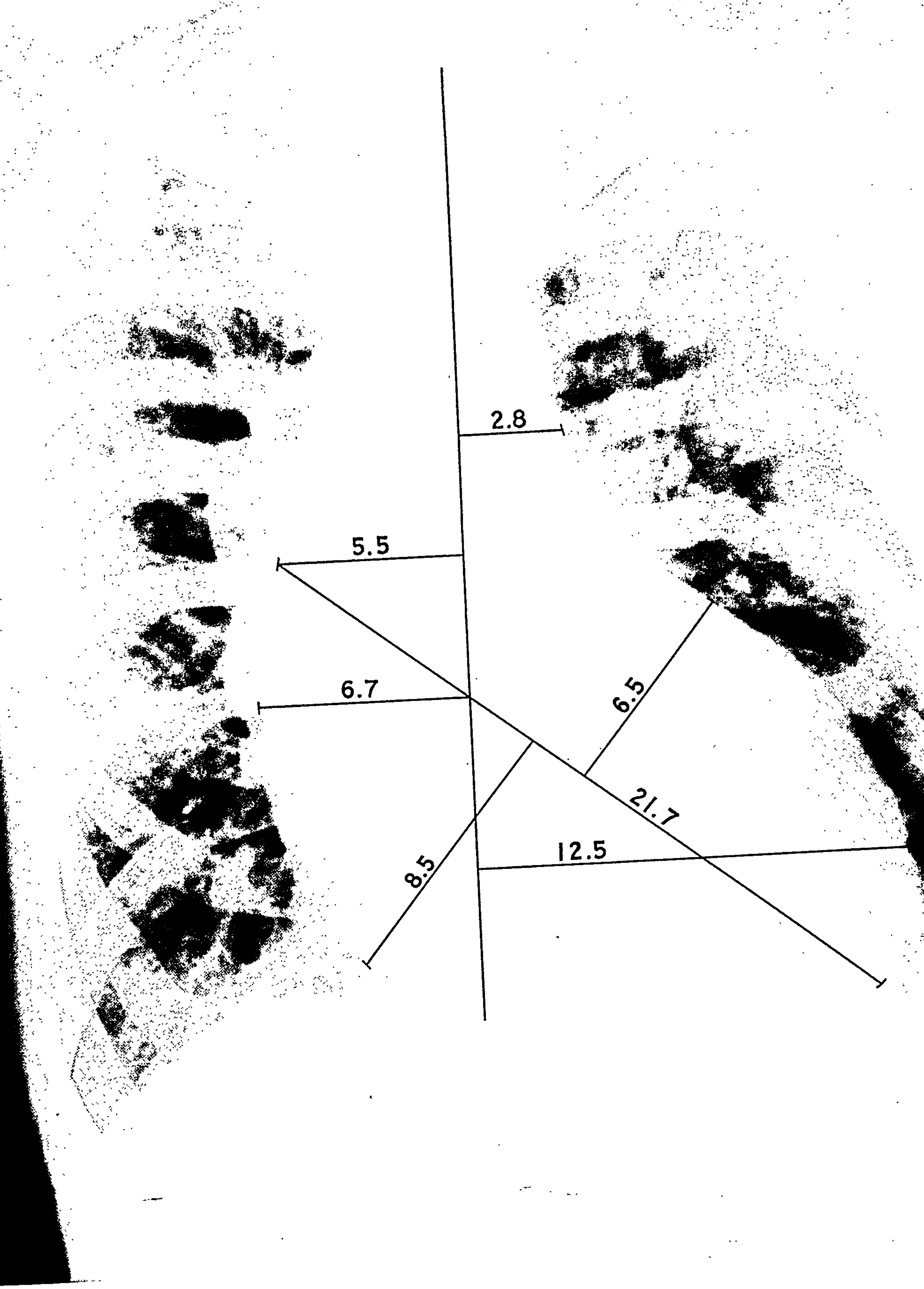
SCIENTIFIC EXHIBITS

COMMERCIAL EXHIBITS

REFRESHER COURSES

ENTERTAINMENT

All resolutions to be acted upon at the annual meeting in Atlanta, should be presented to the RESOLUTIONS COMMITTEE before the Executive Sessions.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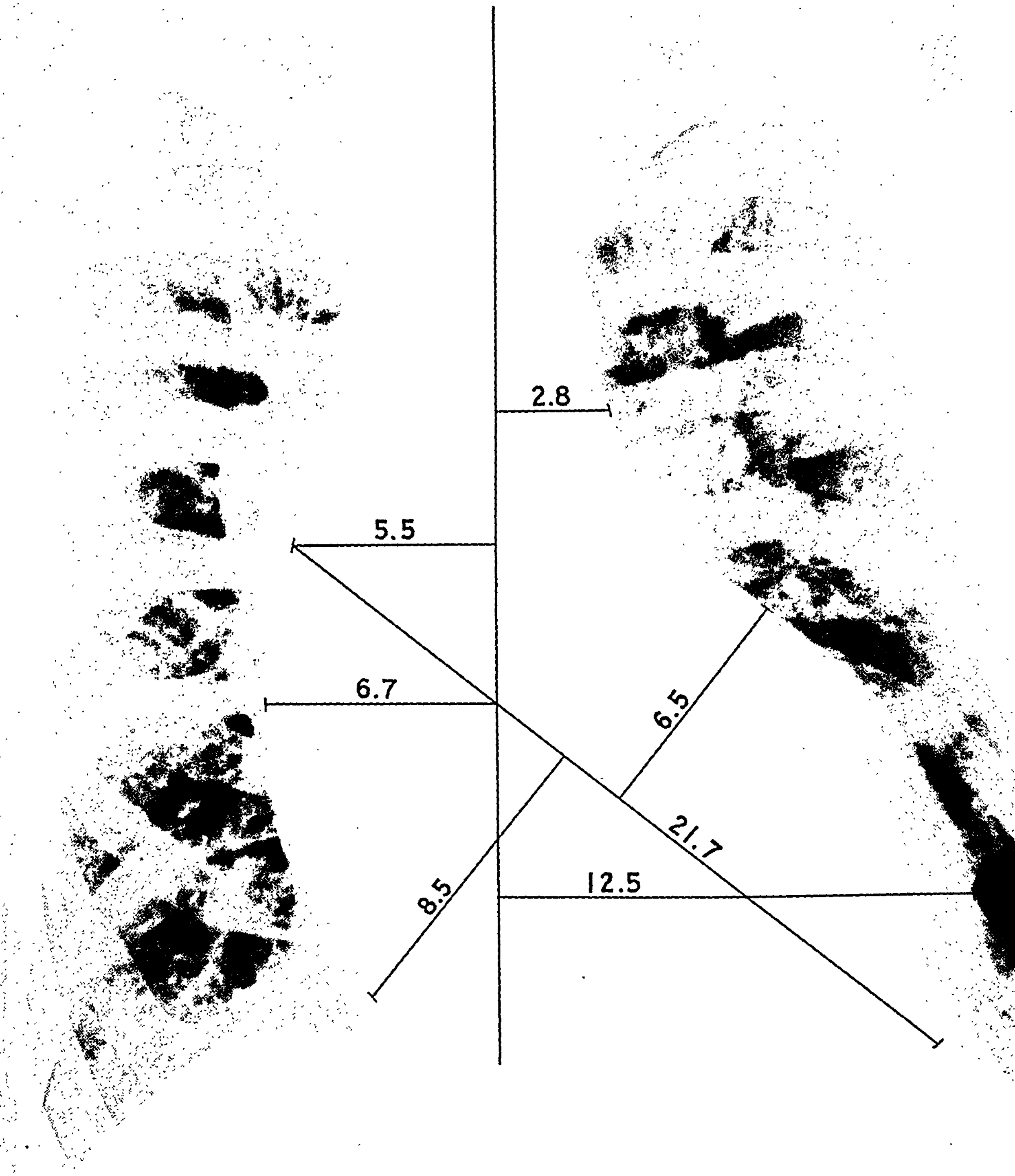
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Technical Factors for Radiograph Reproduced on Reverse Side of this Page . . . .

REGION	Thorax (heart)
POSTURE	Erect
PROJECTION	Postero-anterior
THICKNESS	25 cm.
ANODE-FILM DISTANCE	72″
TUBE FOCAL SPOT	2 mm.
TUBE FILTER	.3 mm.
FILM	Eastman *Ultra-Speed*
SCREENS	Eastman *High-Definition*
KV.P.	78
MA.S.	18
DEVELOPMENT	Kodalk X-ray Developer (3½ min., 65° F.)
FIXATION	Eastman X-ray Fixer

Eastman *Ultra-Speed* X-ray Film . . . Eastman *High-Definition* Intensifying Screens . . . Kodalk X-ray Developer Powders . . . Eastman Prepared X-ray Fixing Powders are made to complement each other. This combination in your laboratory will provide the best assurance you can buy of diagnostically excellent radiographs.

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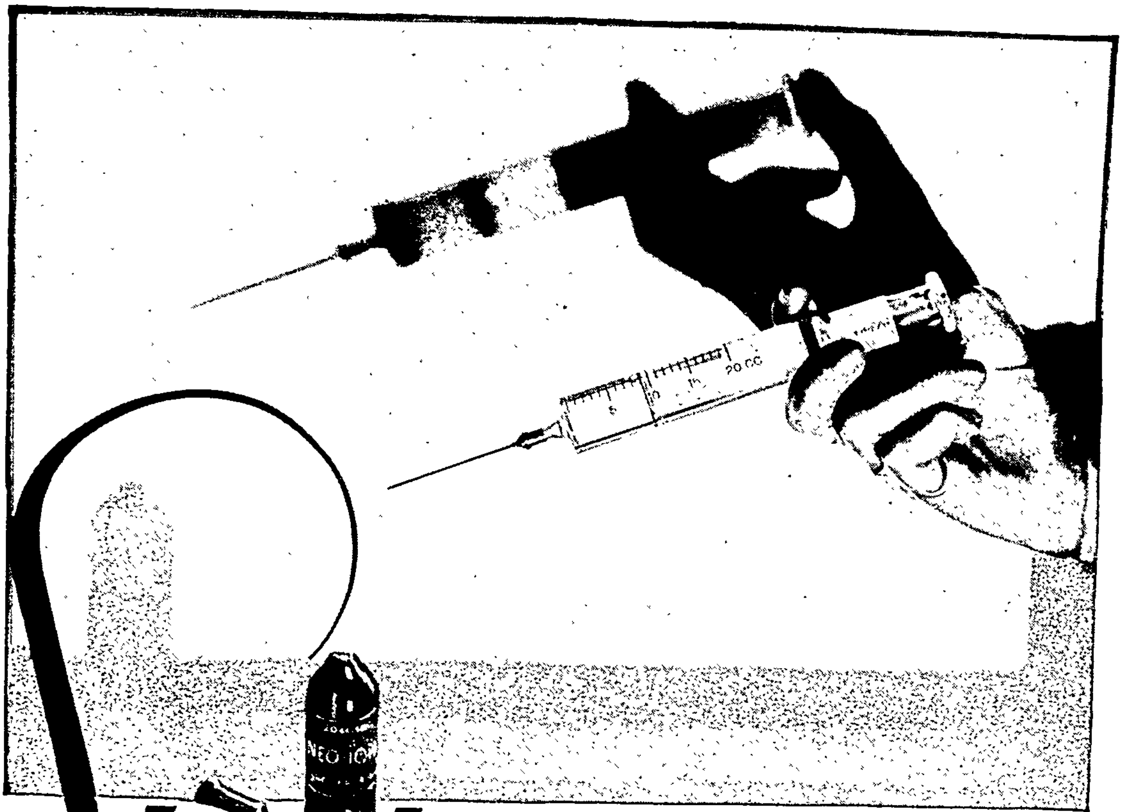

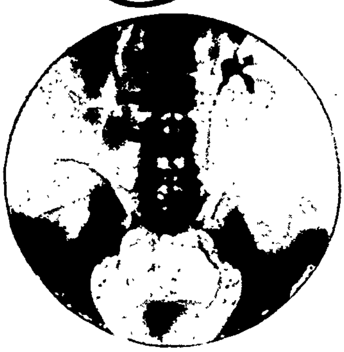

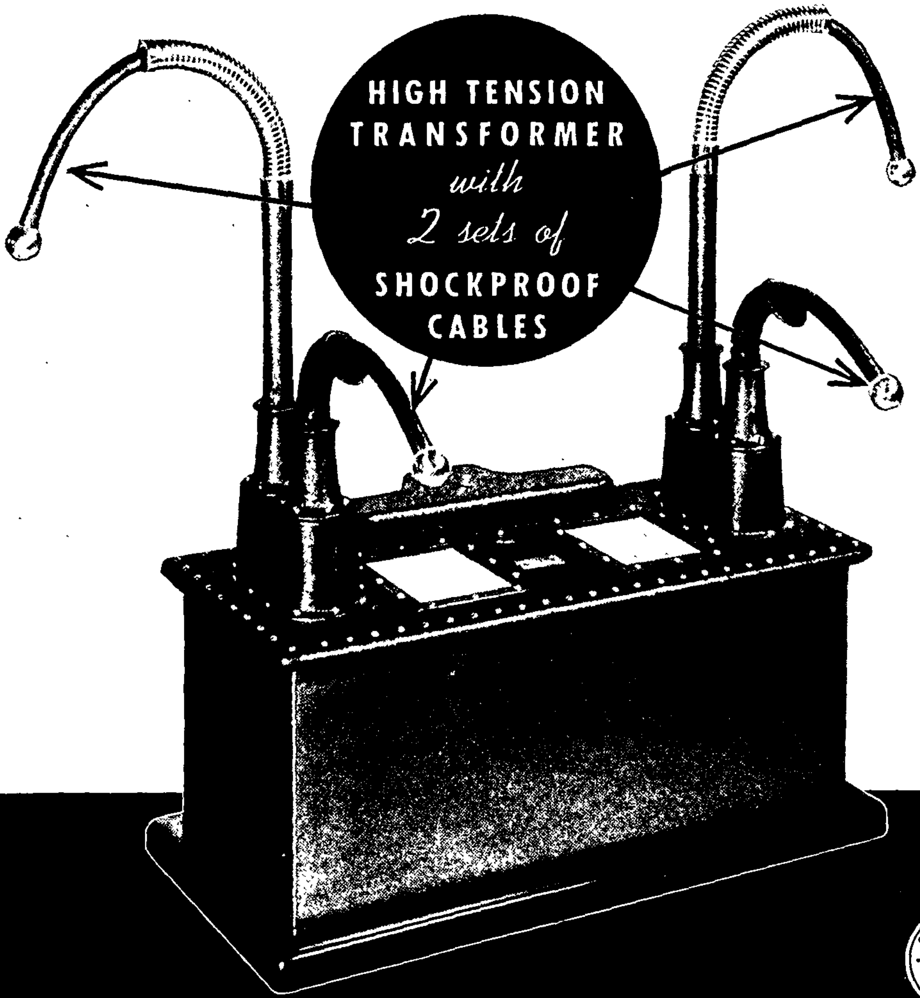
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ROENTGEN KYMOGRAPHIC STUDY OF THE ALTERATIONS IN THE PATHOLOGICAL HEART DURING VALSALVA AND MÜLLER TESTS[1]

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From the Institute of Radiologia de la Faculdad de Medicine de Montevideo

TRANSLATION BY MYRON WRIGHT

THE radiological study of the variations in the form of the heart following the procedures of Müller and Valsalva was made for the first time by Crowden and Harris (1) in a very artificial manner which was not comparable with routine clinical procedures. In the Valsalva test they noted a decrease in the size of the heart because of the difficulty in entrance of the blood into the heart due to an increase in intrathoracic pressure. On the basis of Müller's test, they found that the increase in cardiac volume was due to the increase in blood flow to the ventricles when the intrathoracic pressure was diminished. These results are in consonance with the findings of the physiologists.

Subsequently, Roesler (2) confirmed these findings radioscopically and noted that during Müller's test the volume of the vena cava also increases. He expressed simply the mechanism of the increase in heart volume, by saying that in the Müller test there is an increase in the normal suction effect which the lung exerts on the heart, while, during the Valsalva test, this is diminished.

The first one to study these tests roentgenographically was I. S. Hirsch (3), who noted that in normal humans alterations could be produced artificially which were identical with those observed in some of the cardiopathies. He also showed that during Müller's test the cavities adapt themselves to an overfilling, such as exists in the right ventricle in pulmonary stenosis; that the amplitude of the waves of the vena cava is increased, and that the aortic movement diminishes. During Valsalva's procedure the cardiac cavities adapt themselves to a smaller flow of blood, emptying the ventricles progressively and diminishing the amplitude of auricular and ventricular beats.

Bordet and Fischgold (4) studied the left ventricle roentgeno-kymographically during Valsalva's test and recorded a decrease in its volume, and in the amplitude of its waves, and an increase in cardiac rate.

In a monograph published in 1936 (5), and subsequently in a study in some cases of the systolic movement at the levels of the ventricles of the heart (10), I studied the modifications of the normal and pathological roentgen kymograms, during both tests from the point of view of the underlying lesions, by the concentric kymographic method. This is, in my opinion, the most appropriate method for the study of the waves at the level of the auricles and ven-

[1] This is one of a series of papers contributed by friends and former pupils of I. Seth Hirsch, M.D.

tricles because the slits are in such a position that they almost cut the borders of the heart perpendicularly, if one has taken the precaution of centering correctly.

MATERIAL AND TECHNIC

The material for this work was selected from the patients in the Radiological Diagnostic Service of Heart Diseases of the

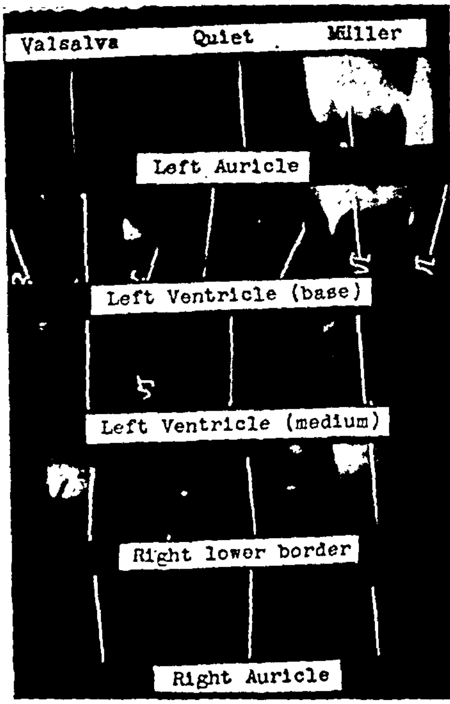


Fig. 1.

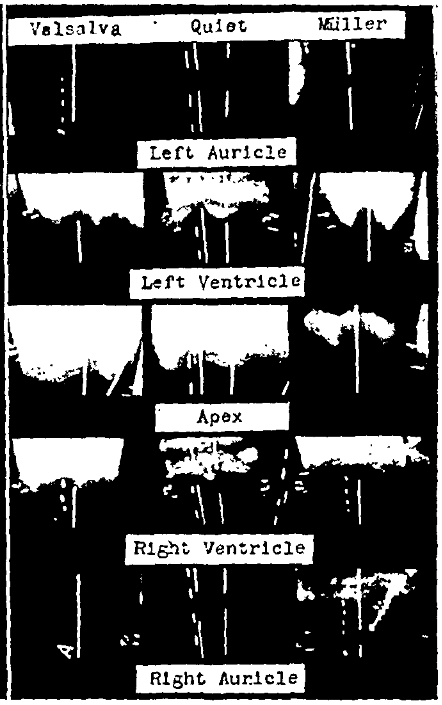


Fig. 2.

Fig. 1. Kymogram of an athletic, muscular, adult male 18 years of age. The heart is normal and there is no previous cardiac history. Diameters: Valsalva, 11.2; Quiet, 12.8; Müller, 13.4. At rest, the auricular impulses are normal, with the major and minor systolic retraction synchronous with the opening of the auricular-ventricular valves. The major filling is seen post-systolic. During the procedure of Müller it is pre-systolic and during the procedure of Valsalva the systolic retraction alone is visible. The left ventricular waves at rest are normal with all the characteristic contours. During the procedure of Valsalva the reduction of the diastolic contours may be observed. During the procedure of Müller the diastolic and systolic periods are accentuated with an increase in the amplitude of the waves which are, however, reduced in the procedure of Valsalva. At the lower border on the right side typical right ventricular waves may be observed (transmitted by the auricle). In the auricle there may be observed impulses similar to those of the left ventricle with the difference that during the procedure of Valsalva the diastole is almost entirely isometric, with complete filling of the ventricle at the end of diastole. During the procedure of Müller the rapid diastole is accentuated. In the right auricle similar phenomena are to be observed with the difference that the maximum expansion during the procedure of Valsalva is post-systolic and in Müller it is pre-systolic.

Fig. 2. Kymogram of a man of 32 years of age with a previous history of rheumatic infection in childhood and with pronounced dyspnea on effort and hemoptysis of one month's duration. Pulmonary examination was negative. The heart findings are those of mitral stenosis with enlargement of the left auricle, a small left ventricle, and abnormal prominence of the pulmonary artery and its branches, with hypertrophy of the right ventricle toward the midline and increase in volume of the right auricle. The heart measurements: Valsalva, 15.1; Quiet, 16.8; Müller, 16.2. There is disappearance of the waves of the left auricle during the procedure of Valsalva and in the Müller tests a substitution by waves of auricular and ventricular type. The waves of the left ventricle reveal the diastolic characteristics of mitral stenosis during the procedure of Valsalva, while during the procedure of Müller they show a normal outline. At the apex and at the lower part of the right border, the right ventricle shows rapid and brisk filling and prolongation of the isometric phase of diastole. These diastolic characteristics are accentuated during the procedure of Müller and reduced during the procedure of Valsalva. No waves were observed in the right auricle in any of the procedures.

Institute of Radiology of the Medical Faculty of Montevideo. They were referred to this service principally from the Cardiac Clinic of Professor J. Montes Pareja, from the medical clinics and wards of Maciel Hospital. Adult patients with practically all types of cardiac lesions were examined and were divided and classified in groups according to the clinical diagnosis. From a group of 3,200 patients were separated those with the clearest clinical picture of pure cardiopathies, and from these a selected number were studied roentgeno-kymographically. From each group so examined, the most typical case was selected because it showed the changes characteristic of the entire group, and then from these cases the most interesting ones were separated to serve as a basis for this work. In the accompanying Table I can be seen the cardiopathies studied, some of them being based on the degree of cardiac insufficiency presented by the patient, and some based on special anatomic alterations which I desired to study.

I have utilized a concentric roentgen kymograph, a modification of the original one of Stumpf (6), which has been described in a previous publication (8). In this apparatus the screen is a steel wheel which contains in its interior thin lead sectors that limit triangular slits, each one of them being 19.5° from the ones on either side of it. These radial slits have a progressively increasing width from the center to the periphery, but not in strict relation with the radius, the purpose of this being to counterbalance the greater transparency of the lung: at 2 cm. from the center the slits are 0.2 mm.; at 4 cm. they are 0.4 mm.; at 6 cm. they are 0.5 mm., and at 12 cm. they are 0.8 mm. wide. The width of the lead sector at 6 cm. from the center is 2 cm. This corresponds to the place where the upper level of the cardiac silhouette usually cuts the slit. Ample tracings can be obtained by this method by using a rotary velocity which permits the coverage of a sector in from 1.33 and 1.6 second. This makes it possible to register two complete cardiac revolutions per sector.

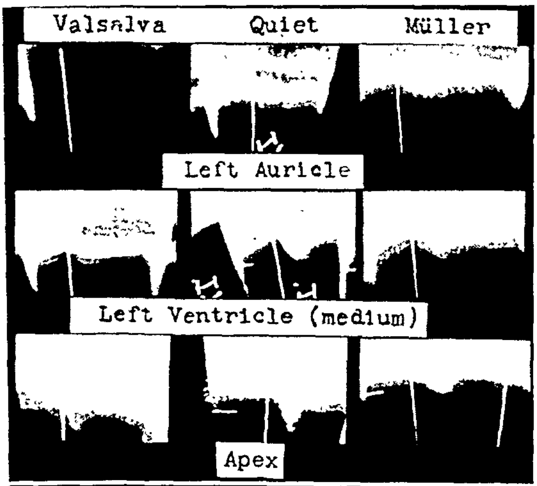
The plate holder with a radiographic film is in a second steel wheel, concentric with the first, and both rotate, supported at the periphery by little wheels, one of these being attached to a synchronized electric motor making it possible to obtain perfectly regular circular movement.

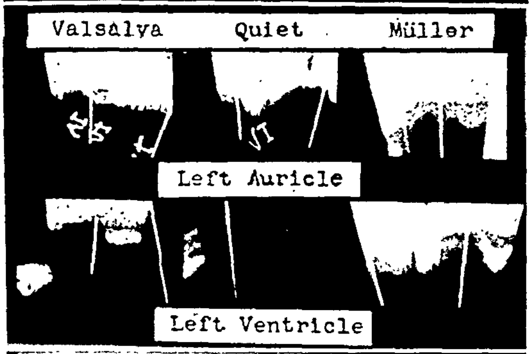
With a special arrangement it is possible to make either one of the steel wheels rotate, obtaining by means of rotating the screen wheel a plane or surface kymogram or when the wheel holding the film rotates, a lineal or step kymogram.

In this work I have reproduced only step kymograms, which are best adapted for this study. In all the sectors obtained a line of reference has been marked which corresponds to the beginning of systole. This was done with a special "comparator" or scale that I previously described (5). This scale is a celluloid film with radiating lines which correspond exactly to one of the edges of the slits. This scale is held on a fixed projection mounted at the center of an ordinary illuminating box, taking care that the point perforates its exact center. The kymographic film is pierced at its exact center, which brings the scale in proper relation with the negative. Finally the negative is rotated in the direction of the course of the tracing to the desired point and then the line of the "comparator" is marked on the negative with India ink. In some kymograms, such other points of the cardiac cycle may be marked as may be of interest in the consideration of the different cardiac chambers.

The distance between the tube and the film was commonly 36 inches. A 10 kw. tube working with 100 ma. and from 80 to 100 kv.p. was used. An anti-diffusion cone was always used (improves the tracings) and modern high speed screens and films, and a longer processing of the film.

The center of the system was placed inside the cardiac shadow at a distance from the borders proportional to the amplitude of movement as observed radioscopically, in order to obtain the greatest length of record in those parts of the contour which have the greatest amplitude.





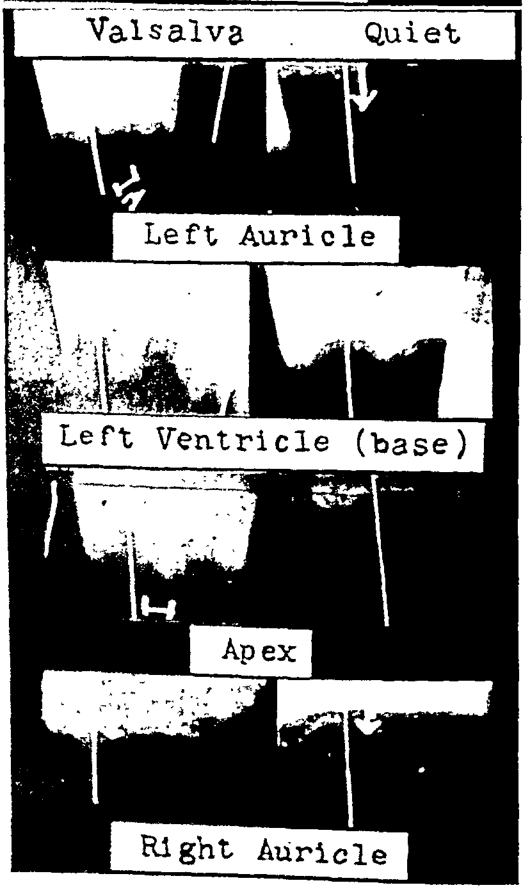


Fig. 3 (*top*). Kymogram of a 24-year-old man with previous history of rheumatic infection in childhood with minimal signs of cardiac insufficiency. There is alteration of the first sound with a soft blowing murmur at the apex. This was more intense in childhood and had the character of mitral insufficiency. Heart measurements: Valsalva, 12; Quiet, 14; Müller, 15.6. The waves of the left auricle are strongly influenced by the ventricular overfilling during the procedure of Müller. In the upper part of the left ventricle, the diastolic waves are normal at rest, with the waves typical of mitral stenosis being seen during Valsalva's procedure, and waves of mitral insufficiency being seen during the procedure of Müller, while at the apex, at all times the characteristics of the insufficiency may be observed. These are smaller in Valsalva and little reduced in Müller.

Fig. 4 (*middle*). Kymogram of a 27-year-old man with atypical acute attack of polyarticular rheumatism of two months' duration without previous cardiac involvement. Beginning one week before admission he had had dyspnea on exertion and presented the typical blowing murmur of mitral insufficiency at the apex. The diameters: Valsalva, 13; Quiet, 15.1; Müller, 15.1. The typical left auricular waves are greatly influenced by the ventricular without observable regurgitation. At rest, there is a protodiastolic expansion that terminates with the opening of the auricular-ventricular valves. The left ventricle revealed the typical diastolic and systolic picture of mitral insufficiency without an isometric period and with contractions which are rapid, brisk, and deep in apnea and during the Valsalva test. During the procedure of Müller they approach an isometric period and the contraction is less deep and more prolonged. In both tests the amplitude of the waves decreases.

Fig. 5 (*bottom*). Kymogram of a young woman 25 years of age with acute and rapidly progressive rheumatic heart disease. Physical examination revealed an intense systolic murmur at the apex, reflected over the precordium and which has the characteristics of mitral insufficiency. Heart measurements: Valsalva, 17; Quiet, 18.5. The waves of both auricles are conspicuous while at rest and a wave of systolic regurgitation which almost disappears on the left becomes more evident on the right during the procedure of Valsalva. At rest, the expansion of the left auricle is so large that it appears synchronous with the systolic ventricular contraction of the middle section of the ventricle.

RESULTS

Three step kymograms were studied in almost all the cases: the first in quiet respiration (Q); the second, six seconds following Valsalva's procedure (V)—forced inspiration, closing of the glottis, followed by forced expulsive effort with the thoracic and abdominal muscles without permitting the exit of air—and finally the third was obtained six seconds after Müller's test (M), (forced expiration, closing the glottis, forced inspiratory effort without permitting the entrance of air). The patients were

rehearsed prior to the exposure and then those kymograms were discarded in which an increase in the transverse diameter during Müller's procedure and a decrease during Valsalva's procedure were not noted. Those cases, however, in which the position was markedly changed were kept, since tests have shown that there are not only changes in volume of the chambers but also changes in position of more or less importance and magnitude in accordance with the findings of Bordet and Fischgold (4). In the doubtful cases the variations in rate were observed, since normally during Valsalva's test there is definite acceleration and, during Müller's, a slowing of the heart.

The reduction of volume during Valsalva's test affected the transverse diameter (measured between the extreme lateral points of the contours). In normal cases the reduction varied from 10 to 14 per cent. In the Müller procedure the increase was only 8 per cent.

In the pathological cases in the Valsalva test, the maximum decrease observed was 17 per cent in some patients with myocardial infarcts classified kymographically as aneurysms of the lateral wall of the left ventricle, without deformity of the silhouette. In well compensated cases of mitral insufficiency the maximum decrease was 15 per cent. The least decreases in the transverse diameter during Valsalva's test were observed in double mitral lesions, with or without lesions of the pulmonary artery, in the multivalvular lesions in pulmonary stenosis, and in the myocardial diseases with a small heart.

The increase in transverse diameter during the procedure of Müller, studied in the pathological cases, may reach 11 per cent, as in the pure aortic insufficiencies and in aneurysm of the ventricle. In the Müller test the minimal increases were observed in mitral stenosis, in mitral insufficiency with cardiac insufficiency, in mitral insufficiency and narrow aorta, in the multivalvular lesions, and in pulmonary stenosis.

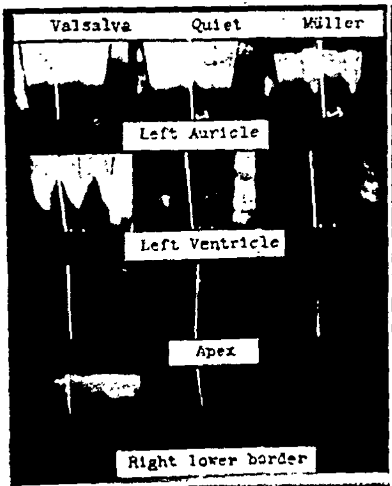
In some cases, changes in the amplitude of the beats of the left ventricle were observed during the tests, there being no increase during the Müller test and a decrease from the normal during Valsalva's. In all the cases of mitral insufficiency with cardiac insufficiency (with or without other valvular lesions), the amplitudes were not increased during Müller's procedure.

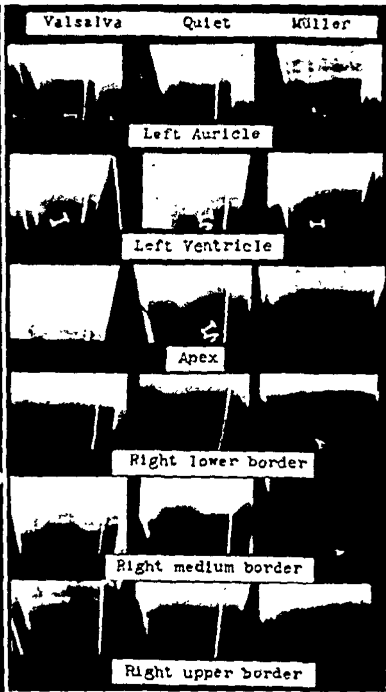
Normally, the form of the waves of the left ventricle varied during the test. In Valsalva's test the diastole becomes progressively slower, and systole more forceful during the period of rapid ejection; while the diastolic periods were more marked and systole was prolonged during the Müller test. In some cases, the shape of the waves varied beyond normal limits. This was most marked in well compensated mitral insufficiency and in aortic insufficiency, in both of which, during Valsalva's test, the diastole assumed a normal aspect. In mitral stenosis with aortic insufficiency, in the resting state, the waves were normal, but during Valsalva's test, they were typical of mitral stenosis and during Müller's test they resembled the waves of mitral insufficiency.

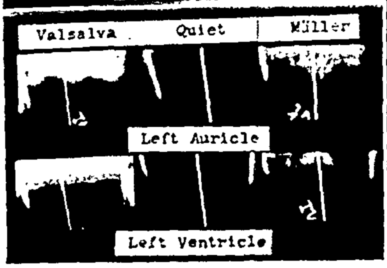
At the apex, the changes were relatively more frequent when the left ventricle formed the apex. In the few cases in which the right ventricle formed it, there were no variations in the normal amplitude. In the majority of these, the amplitude of the beats decreased instead of increasing during Müller's test, thus not being parallel with the amplitudes of the right ventricle studied at the point where the right auricle meets the right ventricle in the right border of the cardiac silhouette.

Pathological changes of the pericardium greatly affect the kymographic waves. In cases of adhesions, kymographic changes may be observed which are in agreement with auscultatory phenomena.

In the four cases of small pericardial effusion studied, the diagnosis was possible in life by means of two radiological signs: (1) the double contour of the cardiac silhouette, and (2) a characteristic alteration of







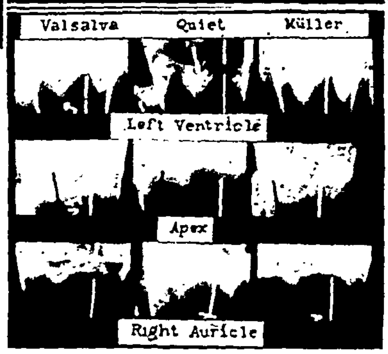


Fig. 6 (*upper left*). Kymogram of a woman, 20 years of age, with a double mitral lesion and without cardiac insufficiency. *Heart measurements: Valsalva, 18.8; Quiet, 18.9; Müller, 19.3. Kymographic* study of the left auricle reveals a reflux wave which disappears during the procedure of Valsalva and creates a sluggish auricular flow which increases in speed with the approach of systole. During the procedure of Müller, the amplitude of the waves is increased. The left ventricle shows diastoles which are typical of mitral stenosis and small abrupt systoles characteristic of mitral insufficiency. Normal variations in the amplitude of the beats are seen. These do not alter the form of the waves and are detected in the middle part of the inferior left arc during the procedures of Valsalva and Müller. In the right lower border there may be seen large auricular waves.

Fig. 7 (*middle, upper*). Kymogram of a 38-year-old individual, with old rheumatic infection, with aneurysmal dilatation of the left auricle, complete arrhythmia and pronounced cardiac insufficiency. Diameters: Valsalva, 17.6; Quiet, 18.2; Müller, 19.2. The left ventricle shows waves of a double mitral lesion which diminish in amplitude during the procedure of Valsalva without modification of their form. During the procedure of Müller they are similarly reduced yet reveal the characteristics of mitral insufficiency. The left auricle, studied in the left median arc, and the superior border of the right auricle show abnormal waves. A large systolic regurgitation may be observed with the opening of the auricular-ventricular valve. This wave of regurgitation is pronounced at rest and reduced in the procedure of Müller and Valsalva. The right auricle does not reveal systolic waves.

Fig. 8 (*lower left*). Kymogram of a 52-year-old man with syphilitic aortic insufficiency and without cardiac insufficiency and a protodiastolic aortic murmur. Heart measurements: Valsalva, 14; Quiet, 16; Müller, 17.6. Waves of protodiastolic regurgitation may be seen in the left ventricle in the procedure of Müller and disappear in the procedure of Valsalva. Also, in the left ventricle the diastole is progressive without characteristic break and the systole lacks isometric periods at rest and during the procedure of Müller. During this latter procedure the amplitude of the ventricular wave is reduced.

Fig. 9 (*middle, lower*). Kymogram of a 40-year-old man with a syphilitic lesion, aortitis, and aortic insufficiency in congestive heart failure. Physical examination revealed a pure protodiastolic aortic murmur. Diameters: Valsalva, 16.3; Quiet, 16.2; Müller, 16.6. The left ventricular waves show full progressive

the waves, "uniform systolic blurring." In one of these cases it was possible to confirm at necropsy the diagnosis made in life. This sign of pericardial effusion is most evident on the left border of the heart during Valsalva's test, and little—if at all—evident during Müller's. In three of these cases the left ventricular volume was not reduced in the Valsalva. In a case in which the left ventricle was small and the right hypertrophied, due to a pulmonary stenosis, the change was much more evident during Müller's test and less during Valsalva's.

Interesting kymographic results were obtained in a case in which there was a full-blown hydatid cyst in the right ventricle, in which there were isolated foci of metastases in the lungs. At the level of the mass, large beats opposite in tune to those of the left ventricle, were observed. It was noted that during Valsalva's procedure the amplitude of the wave did not decrease, despite the decrease of amplitude of the beats of the left ventricle; instead, they appeared larger. On the other hand, with the withdrawal of the left ventricle, during Valsalva's test, the cyst was exposed, while in expansion from Müller's test, the ventricular waves were observed on the outside, and on the inside the cyst waves.

In contrast to this case, there is another in which an immature pericardial hydatid cyst was present. Typical waves of the pulmonary artery were present showing variation in amplitude but not in form of the waves during the procedures of Valsalva and Müller.

In the cases in which there was an interventricular septal defect, congenital in origin, with or without superimposed pulmonary alterations, study of the right ventricle at the apex, and in some cases the inferior right border of the heart, revealed a small expansion, purely systolic, coinciding with the murmur. The expansion decreased or disappeared during Valsalva's test and increased especially during Müller's test. It decreased, disappeared, and increased synchronously with the murmur.

Diverse alterations were observed in the pulmonary arteries in cases of uncomplicated septal defect. Especially a small incisura was noted at the time of termination of ventricular systole which corresponded to the aortic incisura and which was never observed in other cardiac affections, or in those of the pulmonary artery. Another interesting alteration observed in these cases was that the maximal expansion of the pulmonary artery took place at the end of systole. During the tests of Valsalva and Müller the waves varied, taking, during the former, a full and normal shape and during the latter, the beats becoming identical with those normally observed in the aorta.

Alterations of the beats of the pulmonary artery were also noted in other lesions of the pulmonary artery as in one case of double mitral lesion with pulmonary stenosis of possible congenital origin, in which there were observed very full beats in the branches of the pulmonary artery which

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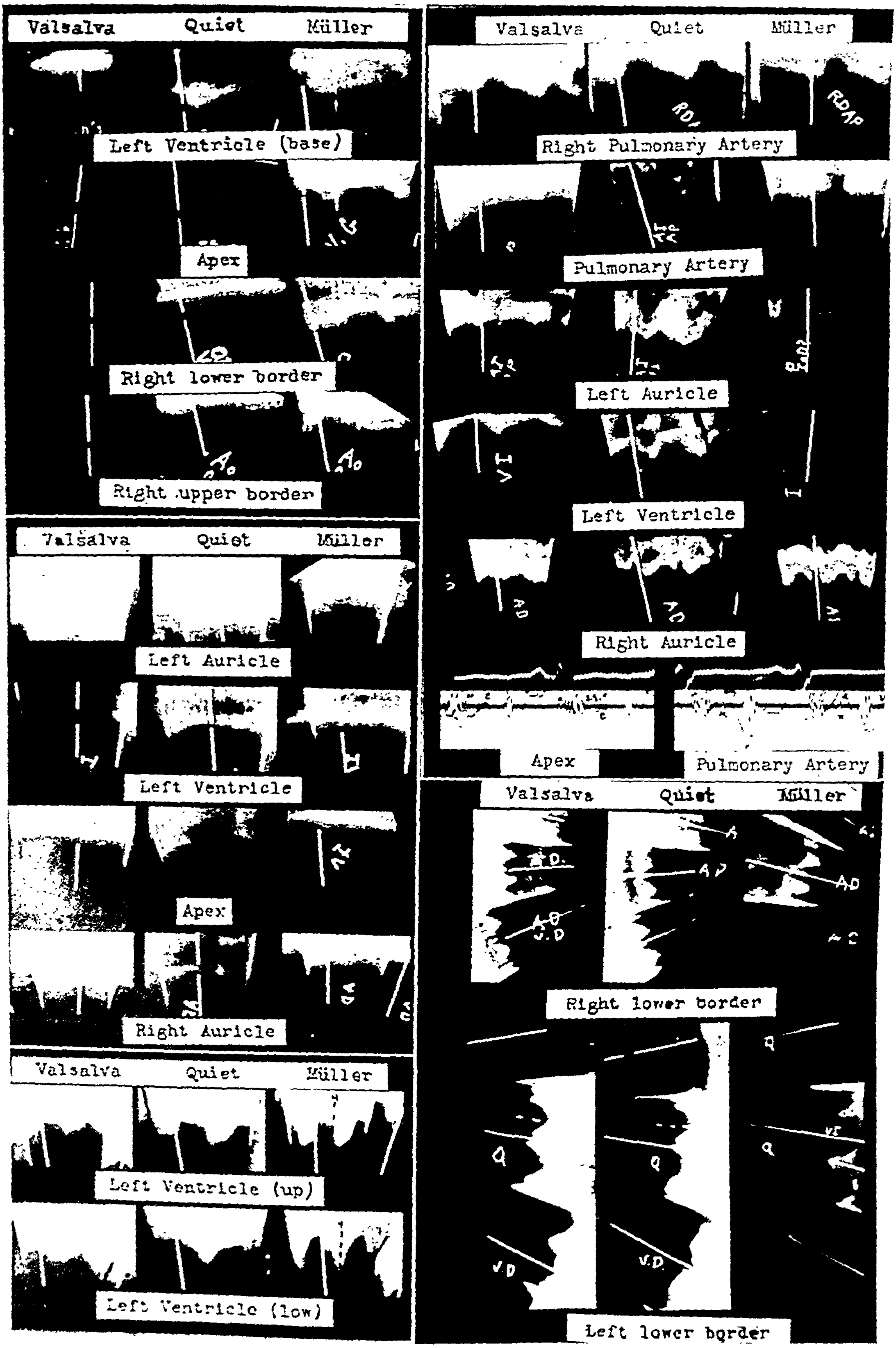
diastole without characteristic break and with small protodiastolic waves of regurgitation and prolonged systole without break. These periods tend to become more normal during the procedure of Valsalva. In the apical area a double curve may be observed radiologically. The appearance of the signs of the uniform systolic disturbances are most apparent in Müller's procedure.

Fig. 10 (*right*). Kymogram of a woman, 32 years of age, with previous rheumatic infection without cardiac insufficiency but with mitral stenosis and aortic insufficiency. Diameters: Valsalva, 10.9; Quiet, 12.4; Müller, 12.8. The systole of the left ventricle is deep and continuous with the expansion that ends with a new systole, but it is interrupted by a gap synchronous with the opening of the mitral valve. This gap almost completely disappears during the procedure of Valsalva, while during the period of Müller it is exaggerated. In rest, the diastolic impulses of the left ventricle are essentially normal but lack isometric periods of systole. During the procedure of Valsalva, the complete diastole at the base shows itself almost exclusively in late diastole, while during the procedure of Müller it is seen principally during early diastole. Systole shows slow and prolonged waves without characteristic breaks. The study of the aorta in the upper margin of the right border reveals typical large waves of aortic insufficiency which are increased in the procedure of Müller and disappear in the Valsalva procedure, being replaced by vena cava waves. The typical wave of the right auricle may be observed, mixed with the ventricular waves at rest, and pure ventricular waves may be observed in the procedure of Müller.


Valsalva
Quiet
Müller
Left Ventricle (base)
Apex
Right lower border
Right upper border
Valsalva
Quiet
Müller
Left Auricle
Left Ventricle
Apex
Right Auricle
Valsalva
Quiet
Müller
Left Ventricle (up)
Left Ventricle (low)
Valsalva
Quiet
Müller
Right Pulmonary Artery
Pulmonary Artery
Left Auricle
Left Ventricle
Right Auricle
Apex
Pulmonary Artery
Valsalva
Quiet
Müller
Right lower border
Left lower border

were markedly dilated, and in the common trunk. Typical waves were observed with small midsystolic shock which cut short the systolic expansion of the artery, and which corresponded to a systolic thrill or systolic pseudo-gallop, audible at that level. This shock disappeared synchronously with gallop, both in Valsalva's test and in Müller's.

In a case of uncomplicated congenital pulmonary stenosis, it was observed that the beats were of the aortic type. They increased in amplitude during Valsalva's test and decreased during Müller's test. Before the beginning of the expansion there was a sudden, deep incisura which did not correspond to any auditory phenomenon and which did not disappear during the tests of Valsalva and Müller, in spite of variations in the amplitude of the beats.

DISCUSSION

The study of the variations of the transverse diameter of the heart after the procedures show us that whenever the post-systolic volume is increased or there is a greater stretching than normal of the myocardial fibers, the Valsalva test produces a greater diminution in the transverse diameter than in the normal.

This change occurs in the left ventricle in well compensated mitral insufficiency, where it seems illogical to admit the existence of residual blood, since at the instant of systole the blood leaves the ventricle through the insufficient mitral valve in addition to the normal or aortic route. But a consideration of the post-systolic residue according to Bohm's criteria (7), the assumption that it may in reality be the sum of a small ventricular residue plus

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Fig. 11 (*upper left*). Kymogram of a 60-year-old man with hypertension, arteriosclerosis, and good compensation. Murmurs were detected in the band of Huchard. Diameters: Valsalva, 16.8; Quiet, 18.3; Müller, 18.8. Ventricular waves, with much prolonged diastole and systole resembling tidal waves, may be observed. The amplitude diminishes normally in the procedure of Valsalva and is accentuated in the procedure of Müller.

Fig. 12 (*upper right*). Kymogram of a 48-year-old man with a congenital heart lesion diagnosed as pulmonary stenosis with a double mitral lesion. Examination revealed moderate cyanosis and good cardiac sufficiency. Diameters: Valsalva, 19; Quiet, 19.4; Müller, 20. In the branches of the pulmonary artery large waves may be observed which show little increase during the procedure of Müller and are reduced without modification of their form during the procedure of Valsalva. While in the common pulmonary trunk a deformed wave is observed at a point which corresponds to the instant at which a systolic snap was detected at this level. A notch is also seen which disappears during the course of the procedure and increases in amplitude during the procedure of Valsalva but is reduced in the procedure of Müller. The left ventricle exhibits typical diastolic waves of mitral insufficiency in spite of the exhibition of rounding at the apex and its behavior in the procedures of Valsalva and Müller as if it were a pure insufficiency. The right auricle exhibits ventricular waves during the procedure of Müller.

Fig. 13 (*left, middle*). Kymogram of a young girl, 16 years of age, with multivalvular rheumatic heart lesions and who had shown some improvement with treatment. Diameters: Valsalva, 14.3; Quiet, 14.5; Müller, 14.4. In all the procedures there may be observed waves with characters which are reduced in amplitude during the procedure of Valsalva and Müller, with the exception of the right auricle which is increased during the former.

Fig. 14 (*left, bottom*). Kymogram of a 40-year-old man who experienced no subjective or objective cardiac symptoms but who, on general physical examination, revealed two small tumors of from two to three centimeters located in the pericardium against the anterior and external portion of the communicating trunk of the pulmonary artery and in the inferior and external portion of the left branch. These are projected in the frontal position in the middle and superior portion of the left inferior arc and have waves opposite in time to the ventricle. This was interpreted as being due to a small hydatiform cyst of the pericardium because of existing eosinophilia. Diameters: Valsalva, 13.5; Quiet, 15.1; Müller, 15.5. The pulsations of the small tumor at the middle possess the qualities described by Wiggers in the pulmonary artery, and in the execution of the procedure of Valsalva and Müller they are reduced and are increased at the same time as the amplitude of the ventricular waves. Their form is not modified but they continue to terminate their expansion much before the onset of systole.

Fig. 15 (*right, bottom*). Kymogram of a young man with multiple pulmonary hydatids following the rupture of a hydatid cyst in the right ventricle. No cysts were found peripherally. Diameters: Valsalva, 12.2; Quiet, 12.7; Müller, 13.8. There was observed in the anterior surface of the heart and projecting into the region of the middle part of the inferior arc a mass with pulsations opposite to those of the ventricle whose expansion begins with the systolic retraction of the ventricle and reaches its maximal expansion at the end of systole. It terminates its retraction with the onset of the new systole. During the procedure of Müller the volume of the left ventricle is increased, revealing its waves imposed upon those of the mass and increasing the amplitude of both. The waves produced by the cyst are ample and sharp. During the procedure of Valsalva, the left ventricular waves are reduced, disclosing the cyst which presents typical plethoric waves.

an auricular residue, explains this apparently illogical situation.

According to this author, the auricular-ventricular septum plays a very special rôle during systole and diastole. Its movement is more marked than that of the ventricular wall; and this whole septum is really nothing more than the auricular-ventricular valve which remains relatively closed during systole and opens almost instantly as soon as diastole begins. An isometric diastolic period does not exist, for all the blood which has accumulated in the auricle empties into the ventricles, the blood being admitted *via* the pulmonary veins to the auricle and thence ejected to the ventricles through the insufficient mitral valve.

The ventricular filling is almost instantaneous, as demonstrated by the rapidity with which diastole is accomplished in these cases. In this way the ventricle is in a position to fulfill Starling's law. It is possible that the muscular fibers are much stretched so that when systole occurs the contraction is very powerful, as Wiggers has demonstrated (9).

This post-systolic residue is really not ventricular, but is auricular-ventricular, as Bordet and Fischgold (4) point out. This residue forms the contour of the systolic ventricular border in the lateral walls of the left ventricle. Bordet and Fischgold also stress the fact that if we desire to isolate the true ventricular post-systolic residue, we must visualize the movement of the auricular-ventricular septum rather than study the lateral contour of the ventricle.

The action of this ventricle on the large post-systolic residue, in which only a very small increase in the transverse diameter is observed in the Müller test, can be explained in Bohm's opinion as follows: When the filling of the ventricle is facilitated by the increase in negative intrathoracic pressure as in the Müller test, there is no change in size, inasmuch as at the beginning of diastole the blood which descends from the auricle in a way hastens ventricular diastole, filling the ventricle completely. In other words, in incompetence of the mitral valve, the auricular pressure is so high that the change produced by the Müller test is insufficient to affect the inflow into the ventricle.

If mitral stenosis is superimposed on the insufficiency, or if a difficulty in passage of blood from auricle to ventricle exists, the equilibrium is upset; or, better still, the unity of the post-systolic auricular and ventricular residues is destroyed. In the first case both are functionally the same; now each one has its individuality. In that case a reduction of the transverse diameter during the Valsalva test is not observed inasmuch as the ventricle itself forms a small post-systolic volume in spite of the fact that the auricular residue may be great.

In those cases in which the equilibrium of the residue has been broken, there is a great wave of systolic reflux at the level of the contour of the left auricle similar to that which is observed in the right auricle in tricuspid insufficiency with venous hypertension. This phenomenon is also observed in the mitral insufficiencies with cardiac insufficiency which provokes an increase in the pressure within the left auricle, not through stenosis or insufficiency of the orifice, but through a residue from the left ventricle incapable of expelling all the blood which the pulmonary circulation sends to it.

This equilibrium can also be broken by a different mechanism when the auricle fibrillates. In such a case there is no systole of the auricle; then the physiological emptying is not very great, it is sufficient to break the equilibrium of the auricular pressure, and if auricular hypertension appears, a wave of reflux can be visualized which may end just at the moment of opening of auricular-ventricular valves.

The waves of systolic reflux in the auricles were observed only in those cases in which an imbalance existed between the post-systolic residues; therefore, there may exist an insufficiency of the left heart due to a difficulty in the passage of blood from the auricle to the ventricle, or to an

auricular fibrillation, which makes the this blood will collide with it and variable

Left Auricle			Right Auricle	Apex	Right Lower Border		
.	Ap.AVV.	Vent. t.			Syst. Ref.	Vent. t.	Auric. t.
	n	......	n	....	...	M>Q>V	......
	n	M	....	Q>V>M	...	M>Q>V	......
	g	M>Q>V		Q>V>M	...		
	g	Mx Q>V					
	n	......	Syst. ref.	....	...		
	n	......	g	V>Q	...		x
	.....	x	AVV-Q>V>M	Q>V>M	...	......	fib. t.
				d.c.			
	M>Q>V	......	M-Vent. t.	Q>V>M			
	M>Q>V	......	Q>y>V	Q>V>M	...	M>Q	V
				M>Q>V	...	M>Q>V	......
					...		
	n	......	M>Q>V				
	w	......	AVV-Q>V>M	....			
							M>Q>V
				{amp.V>M>Q ref. M>Q}			
	n	......	n	M> Q>V			
	n	......	alt.				
				V> Q>M			
			M				
			alt.	{amp. Q>V s.ref. Q>V}	Q > V		
			n				
				{amp.M>Q>V s.ref.M>Q>V}	M>Q		
			n	alt.			
				alt.			

affected region. The blood, therefore, passes without obstacle from the ventricle to the aorta. If a small residue is present,

tients with aortic stenosis or insufficiency with cardiac insufficiency, illustrates the parallelism between this phenomenon (that

auricular fibrillation which makes the evacuation difficult. The expansive systolic wave of the auricle increased during Müller's test and decreased during Valsalva's. This at first glance appears illogical, considering that during the first test the intraplural pressure is less, and for that reason less blood leaves the pulmonary veins. But during that test a secondary alteration exists, which is the increase in amplitude of the beats of the ventricle upon increasing its post-systolic capacity; and, for that reason its muscular fibers are more distended, fulfilling Starling's law with a greater contractile energy. This increase in myocardial energy will result in an increased systolic pressure, and therefore, an increase in reflux through the auricular-ventricular valve; to this is added a poorer adaptation of the valves, inasmuch as the increase in volume of the ventricular cavity stretches the pillars, and the approximation of the valves is inadequate. During Valsalva's test this reflux disappears by a reverse mechanism.

The reduction of the transverse diameter in the Valsalva in old myocardial infarcts is still greater than in pure mitral insufficiency. The same condition occurs in those cases of myocardial degeneration in which there is no change in the cardiac silhouette suggestive of cardiac aneurysm. I believe this phenomenon may be explained on the basis that during ventricular systole the expulsion of the blood cannot be what it is normally, because, in cases in which there exists a zone of altered contractility, at the end of systole there is a residue of blood equal to the blood which has not been mobilized due to the defect in contraction (secondary to the infarct zone).

During the Valsalva test, an external expulsion of the previously mentioned pathological residue is effective. The new diastole finds this region free, and systole impels the blood inside the ventricle in the direction of the aortic valve, without meeting an inert mass of blood in the affected region. The blood, therefore, passes without obstacle from the ventricle to the aorta. If a small residue is present, this blood will collide with it, and variable interference follows.

During Müller's test, this residue will be artificially increased instead of having been annulled as in Valsalva's test. At the beginning of systole, the blood in the region of the apex is set in violent motion colliding with the inert mass, resulting in a collision between the mass in motion and the inert mass of blood. The contour of the heart at this level in the kymogram shows a great systolic expansion of short duration. This expansion is only the representation of the radiated distribution of the force set free by the impact of blood in motion with blood at rest.

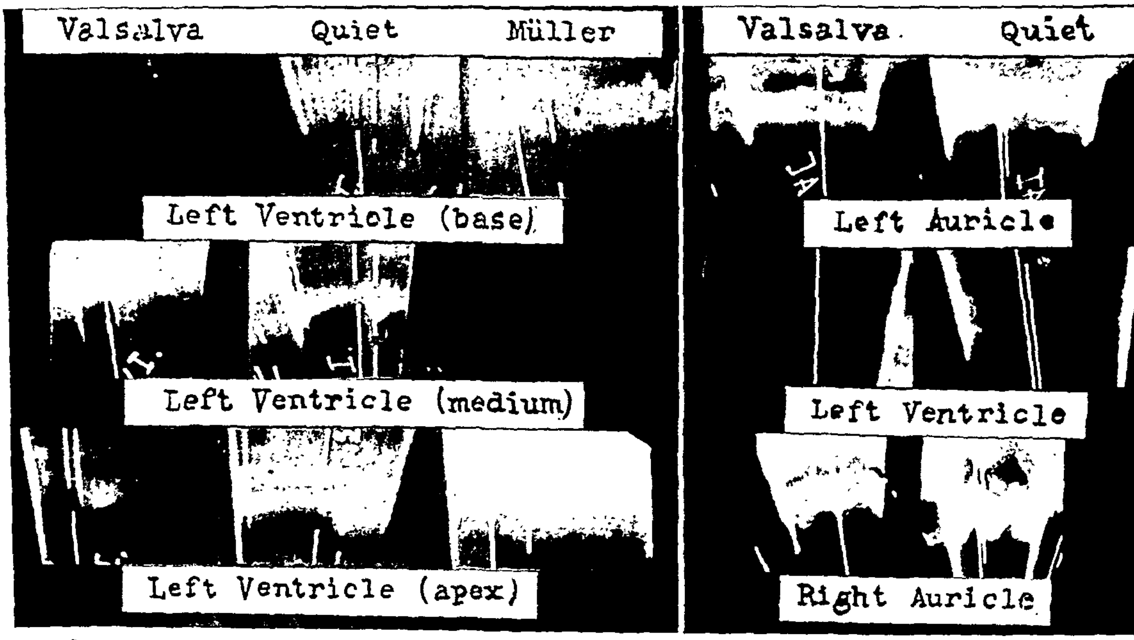
This zone generally is found in the medial part of the left border of the left ventricle, many of these patients showing E. K. G.'s of the T1 or T3 type.

If we were dealing with true aneurysms of the ventricle, we should observe at this level, an expansion which would begin at systole, reaching its maximal point at the instant at which the aortic leaflets open. This expansion would decrease slowly until the instant when rapid ejection ends completely at the end of systole. Or it would show a curve resembling that of the interventricular pressure. No case even in the Müller test when the phenomenon is almost always more evident, was observed.

This explains why it is indispensable to put patients who have recently suffered a myocardial infarction on a low food intake with complete rest.

In this way, the post-systolic residue is reduced, this residue being the direct cause of the impact which the ventricle suffers upon initiating the movement of the mass of blood in its cavity. This violence damages the infarcted wall and should be prevented, bearing in mind that not only the impact in relation to the intensity of the contractile energy set free, but also the importance of the residue.

The great increase in the transverse diameter during Müller's test in the patients with aortic stenosis or insufficiency with cardiac insufficiency, illustrates the parallelism between this phenomenon (that



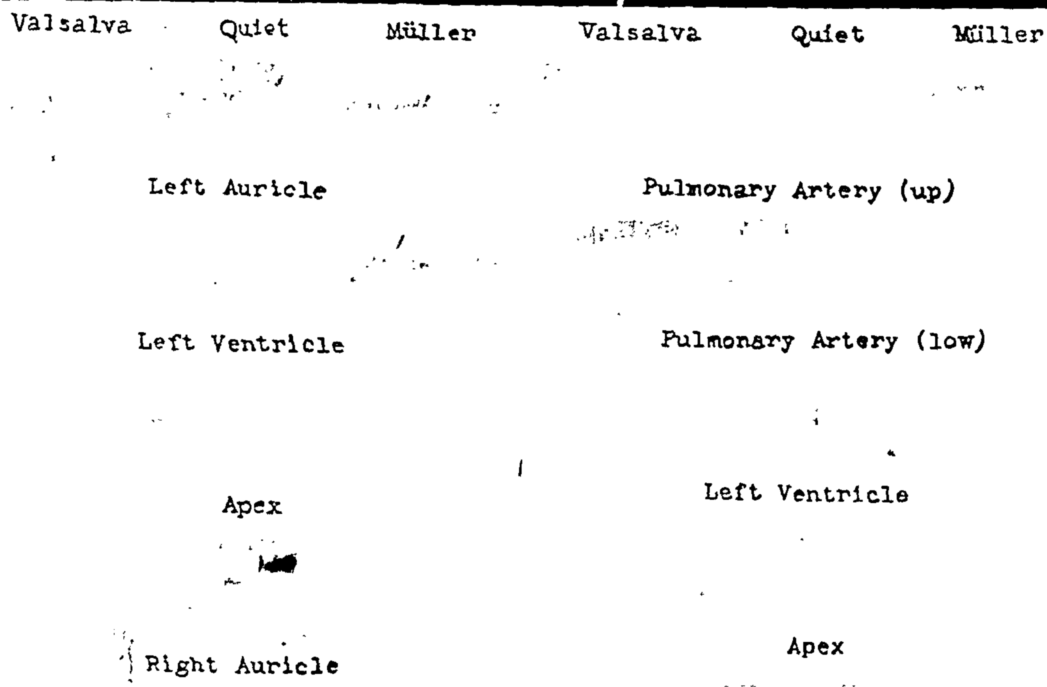


Fig. 16 (*upper left*). Kymogram of a 55-year-old man who sustained an infarct of the myocardium five months before. This was proved clinically and by the electrocardiogram. The E.K.G. reveals, in lead III an enlarged Q wave, inverted T wave, and in lead IV, absence of a Q wave. Diameters: Valsalva, 14.7; Quiet, 15.7; Müller, 17.5. In the inferior part of superapical region of the left inferior arc, in the frontal position, there may be observed a zone of thickening (adhesive pericarditis) with altered waves showing a sharp and short expansion. These are reduced with the protosystolic retraction and disappear completely during the procedure of Valsalva. They are larger and longer during the procedure of Müller.

Fig. 17 (*lower left*). Kymogram of a 51-year-old syphilitic woman who suffered from angina and had a left ventricular gallop, a protodiastolic murmur of the aorta, and fusiform aneurysmal dilatation of the aorta. The E.K.G. reveals a PR interval of 0.23 second and inverted P wave in leads I and II. Diameters: Valsalva, 11.5; Quiet, 13.8; Müller, 14.8. The waves of the left ventricle are very large at the apex and show an abnormal diastolic convexity. Their amplitude is reduced without altering their shape during the procedure of Valsalva, while, during the procedure of Müller, the diastole shows rapid filling characteristic of mitral insufficiency. In the middle and superior portion of the inferior left arc there may be observed a brisk, short expansion during protosystole which almost disappears during the procedure of Valsalva and reduces with appearance of a normal diastolic element during the procedure of Müller.

at first glance appears illogical in hearts which are large) and the unsuspected capacity of the force which is characteristic of them. These are patients with a ventricular hypertrophy compensating valvular lesion, which have an almost normal reserve sufficient to satisfy a transitory demand for more contractile energy.

But not all the cardiopathies can adapt themselves in such a manner to the modification of the intrathoracic pressure: mitral stenosis, mitral insufficiency and mitral stenosis, aortic and pulmonary stenosis, and the multivalvular cardiopathies do it in a very poor way. It can be shown that all those lesions which delay the flow of blood to the heart, impede passage from one cavity to another, or greatly impede the exit of blood to the great or small circulation result in a degeneration of the ventricular muscle. If the transverse diameter is but little changed these patients have a good prognosis; except that always they are unable to do any appreciable work without showing dyspnea.

Contrary to what would appear at first glance, the variations in shape of the waves of the left ventricle during the tests of Valsalva and Müller are not very great, and are in reality (in almost all cases) variations similar to those observed in normal waves which can simulate characteristic pathological alterations, as Hirsch (3) has noted.

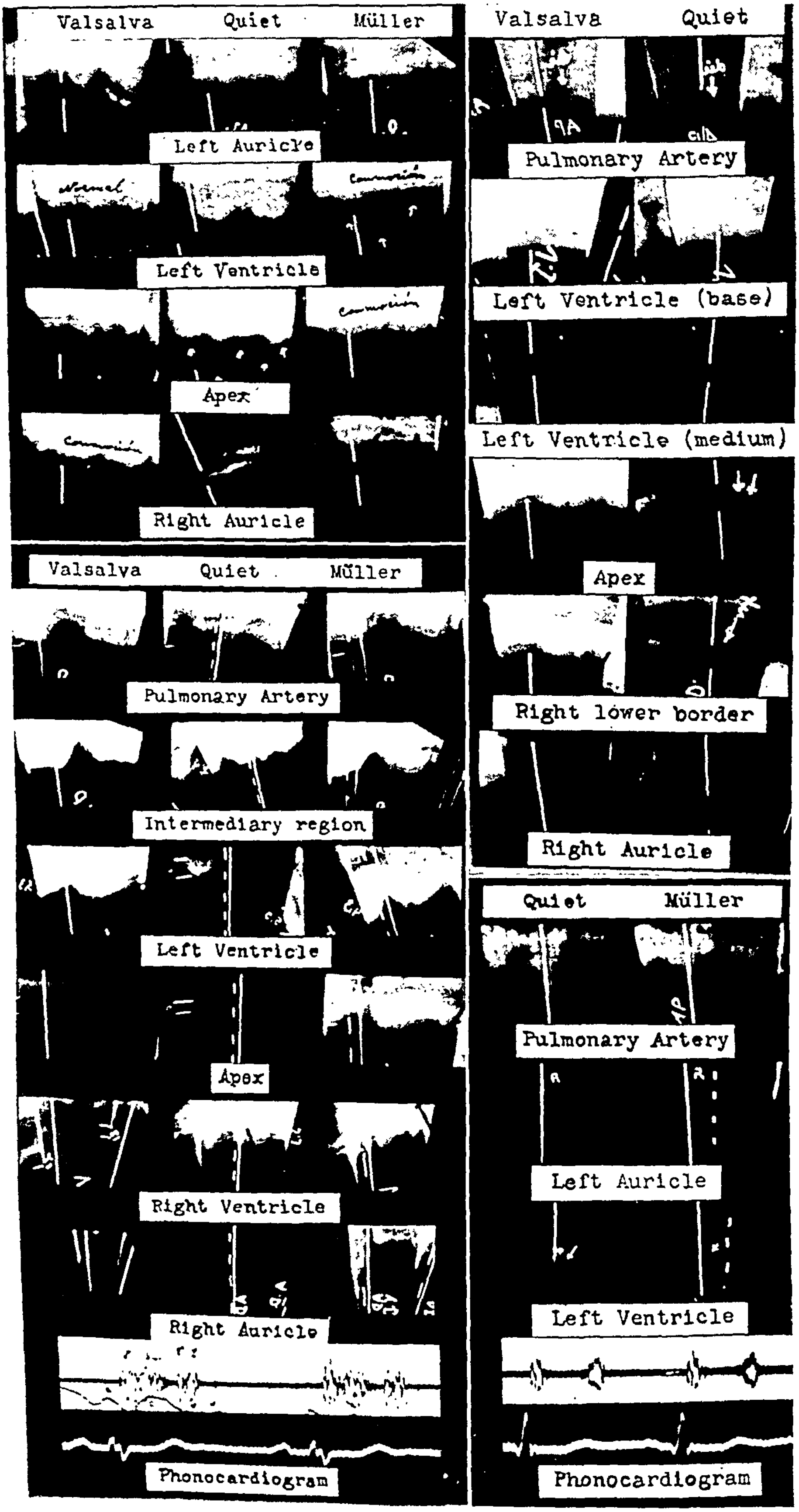
Great alterations in shape were observed only in those cases in which there was a post-systolic plethora as in decompensated mitral insufficiency, aortic insufficiency, or mitral stenosis showing in the Valsalva test a decrease in aortic reflux due to lower pressure in the vessel. The diastoles are more typical in mitral stenosis associated with other lesion, but the amplitude becomes abnormally great due to the hypertension developed in the auricle when the blood of the lung is impelled toward it. During Müller's test, the ventricle increases the aortic pressure and, therefore, the aortic reflux becomes more evident; and on the other hand, upon dilatation of the heart, the passage of blood during diastole through the auricular-ventricular valves occurs with greater ease because there is no blood in the cavity when it reaches there. This diastole of mitral insufficiency is nothing more than the exaggeration of a normal phenomenon in a pathological state.

The normalization of diastole during Valsalva's test, in the well compensated case of mitral insufficiency, is explained by the increase in intrathoracic pressure which compresses the heart, reducing its diastolic volume by which the muscular pillars which were stretched impeded the closing of the valves, now permits them to close.

In cases of communication between both ventricles due to a congenital anomaly, one observes in the right ventricle a short dilatation in the first instant of systole which always ends before diastole. I attribute this dilatation to the impact of the stream of blood which passes through the septal orifice and then crosses the ventricular cavity to the wall. This dilatation ought not to be confused with the dilatation proper of the right auricle in the middle and at the end of the systole due to physiological filling of the same, inasmuch as this expansion always ends before the end of systole, while the true auricular wave ends just at the moment of opening of the

Fig. 18 (*upper right*). Kymogram of a 38-year-old woman with cardiac insufficiency who had suffered from nephritic hypertension for 19 years. She had had attacks of pulmonary edema and succumbed, six days following this examination, to progressive cardiac insufficiency. Diameters: Valsalva, 12.7; Quiet, 13.7. The waves of the left ventricle are altered most. The diastolic limbs are shorter than systole, due to the very large systolic and diastolic isometric period. A reduced amplitude of the wave was not observed, in spite of a substantial reduction of the horizontal diameter of the heart.

Fig. 19 (*lower right*). Kymogram of a 26-year-old woman with congenital pulmonary stenosis and typical cyanosis but without cardiac insufficiency. Diameters: Valsalva, 10.7; Quiet, 11; Müller, 11.2. In the lower part of the common pulmonary trunk there may be observed waves of vascular pattern which begin with a short deep incisura which is increased in amplitude during the procedure of Valsalva and is reduced during the procedure of Müller. It is synchronous with the apical waves, those of the inferior right border, but not with those of the left ventricle.


Valsalva Quiet Müller
Left Auricle
Left Ventricle
Apex
Right Auricle
Valsalva Quiet Müller
Pulmonary Artery
Intermediary region
Left Ventricle
Apex
Right Ventricle
Right Auricle
Phonocardiogram
Valsalva Quiet
Pulmonary Artery
Left Ventricle (base)
Left Ventricle (medium)
Apex
Right lower border
Right Auricle
Quiet Müller
Pulmonary Artery
Left Auricle
Left Ventricle
Phonocardiogram

auricular-ventricular valves, or in diastole. In confirmation of this I ought to mention that, moreover, the reflux is observed at the apex of the heart, which negatives completely its auricular nature.

In a case in which pulmonary stenosis was superimposed, there was observed in the waves at the systole, an incisura similar to the aortic incisura. It is interesting to note that I have never observed this alteration in the numerous cases of diverse congenital or acquired affections of the artery which I have had occasion to study, and in which no communication existed between the ventricles.

It seems as if this notch and the aortic notch are exactly the same phenomenon. The action of Valsalva's test upon the wave of reflux in the intraventricular communication is very obvious inasmuch as it tends to prevent it by increasing the pressure in the right ventricle, increasing the resistance of the pulmonary circulation, and decreasing the pressure in the left ventricle. During Müller's test this wave of reflux increases enormously as a result of the fall in pressure in the right ventricle through the decrease of the resistance in the pulmonary circulation, and the pressure in the left ventricle increases as a result of the increase in the amplitude of its waves, and the absence of variation in the resistance in the general circulation. In all these cases, the characteristic murmur is diminished, parallel with the amplitude of the wave of reflux during Valsalva's test, and the murmur is increased during Müller's.

In a case in which there existed an accessory cavity in communication with the cardiac cavities, it was possible to observe the characteristics of these cavities, as when a hydatid cyst opened into the right ventricle. The pulsations of the cavity were opposite in time to those of the left ventricle. It expanded until the end of systole and contracted rapidly until the end of diastole.

Upon studying Valsalva's and Müller's tests, it was observed that during the former, the left ventricle, upon decreasing in volume, receded, leaving the cavity which showed full amplitude of the waves. During Müller's test, the left ventricle increased in volume, sailed past the cavity,

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Fig. 20 (*upper left*). Kymogram of a 25-year-old man with congenital pulmonary stenosis with typical cyanosis and in moderate congestive failure. Diameters: Valsalva, 16.2; Quiet, 16.4; Müller, 16.5. The left ventricular waves are much more marked during the procedure of Valsalva and are reduced to normal in the procedure of Müller. In the middle portion of the inferior left arc and at the apex, there is a double outline opposite high waves with characteristic uniform systolic blurring movement. These are seen at rest in the procedure of Müller, while at the right border of the heart the waves are normal and high in the procedure of Müller and altered in the procedure of Valsalva.

Fig. 21 (*upper right*). Kymogram of a 25-year-old woman with a congenital heart lesion diagnosed during life as a patent interventricular septum with reversal of blood flow. She died three months afterward of a complicating endocarditis and the clinical diagnosis was confirmed at necropsy. Diameters: Valsalva, 15.2; Quiet, 16.4; Müller, 16.5. The waves of the left ventricle lack the normal appearance during the procedure of Valsalva and are reduced in amplitude. At the apex and lower border on the right side of the heart shadow, a protosystolic expansion may be observed which is reduced in amplitude and duration during the procedure of Valsalva. The pulmonary artery shows great alteration of its waves with maximum expansion telesystolic. An incisura may be observed which corresponds to the end of systole. At the level of the right auricle no wave may be observed.

Fig. 22 (*lower left*). Kymogram of a 33-year-old woman diagnosed as a congenital cardiac with patent interventricular septum and pulmonary stenosis without cardiac insufficiency but with slight cyanosis. Diameters: Valsalva, 14.8; Quiet, 15; Müller, 14.8. The kymograph reveals apical waves with mid-systolic expansion which disappear in consonance with the murmur during the procedure of Valsalva and are increased during the procedure of Müller. The waves of the pulmonary artery are greater than those of the aorta. This is increased during the procedure of Valsalva, while during the procedure of Müller the arterial expansion begins with a slow protodiastolic ascent which is broken up by a brisk mesosystolic expansion of a wave which is equal to that observed at rest (the sign of a patent ductus Bottali).

Fig. 23 (*lower right*). Kymogram of a 26-year-old woman who had suffered for the past three years from polyarticular rheumatism. She was well treated and presented from the first a musical telesystolic murmur which was small and harsh and located at the apex. Actually, in the radiographs, there may be observed many calcified pericardial plaques. Diameters: Quiet, 12; Müller, 12.8. The kymogram reveals left ventricular waves with a large systolic wave of reflux and the pulmonary artery is of the congestive type. The waves of the left ventricle are typical of mitral insufficiency in diastole. In systole, they are interrupted by a variation which corresponds to the onset of the musical murmur and ends with the completion of the expansion of the reflux auricular wave. This variation is most conspicuous during the procedure of Müller.

and increased the amplitude of its waves in a normal way. This was not the case with the waves of the accessory cavity which became ample and water hammer. I believe that the water hammer character may be due to the decrease in the resistance of the small circulation during Müller's test, in the same way that the pulse becomes irregular in peripheral circulatory insufficiencies; and they are increased owing to the increase of the amplitude of the right ventricular pulse during Müller's test.

If the cavity had been in contact with and had opened into the left ventricle, its beats would have been modified in the same manner as are the aortic beats during the test, decreasing its amplitude during Valsalva's test and increasing it during Müller's test.

Finally, if the cavity were in contact with neither cardiac cavity, as was observed in another case, it would transmit the beats of the chamber upon which it was located, without deforming them, varying in the same way that the waves varied during the tests.

The study of the small pericardial effusion showed the existence of the phenomenon of the uniform systolic vibratory movement on the left border, together with this double contour. The phenomenon of uni-

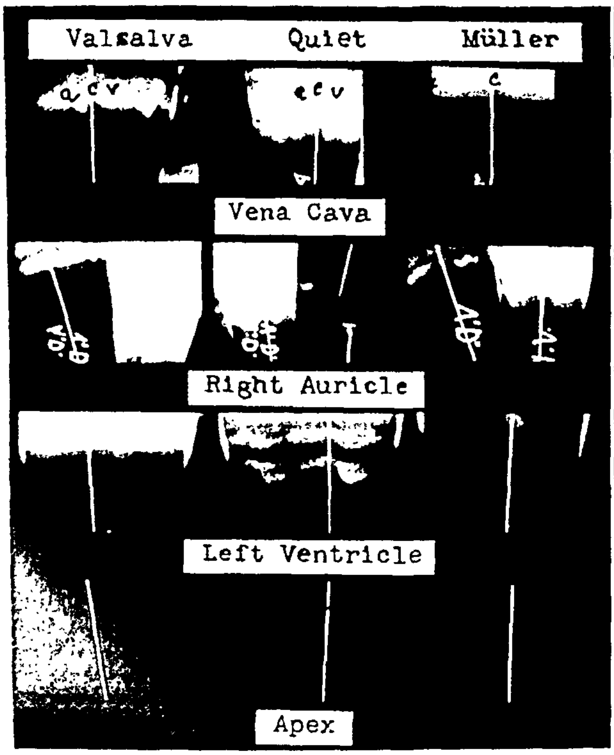

Fig. 24.

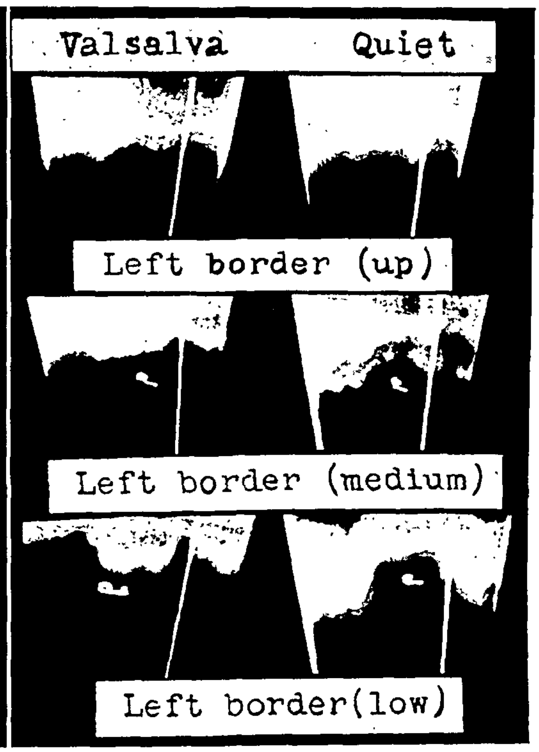

Fig. 25.

Fig. 24. Kymogram of a 27-year-old woman who suffered from extrasystoles, dyspnea on exertion, and arterial hypertension, but who was completely negative on physical examination with the exception that a slight pericardial effusion was suspected radiologically by the existence of a double contour through the inferior left arc. This was most marked at the apex and at the base of the heart. She responded to antibacillary treatment and obtained complete cure but the changes persisted. Diameters: Valsalva, 11.8; Quiet, 12; Müller, 13. The sign of the "uniform systolic blurring" was present at the point altered by the maximum systolic expansion. This is lessened and almost disappears during the procedure of Müller and is accentuated during the procedure of Valsalva. In the upper portion of the right contour of the heart, the waves of the vena cava may be observed with the waves showing very prominently at rest and even more so during the procedure of Valsalva. The accentuation of the waves may be observed principally in the auricle and ventricle in the procedure of Müller.

Fig. 25. Kymogram of a 29-year-old woman with rheumatic pancarditis who died a few hours after this examination. Necropsy revealed the endocarditis and a pericardial effusion of 400 c.c. Diameters: Valsalva, 14.2; Quiet, 15.2. Radiographically there may be observed a double outline in the whole inferior left arc and the waves are altered most with the characteristic of "uniform systolic blurring." This change is best shown in the procedure of Valsalva.

form systolic blurring movement was more evident during Valsalva's test than at rest, and more at rest than during Müller's (disappearing almost completely in order to make room for the full ventricular beats), in those cases in which the left ventricle was normal or at the most, showed some hypertrophy.

In a case in which the right ventricle was the larger, the opposite condition was observed, for the phenomenon was more evident during Müller's test. In this condition there was also observed a double contour and the uniform systolic blurring movement in the inferior part of the right border of the heart, and at this point the phenomenon was more evident during Valsalva's test than at rest and at rest more than in Müller's test.

The extent of the phenomenon is in direct relation with the thickness of liquid interposed between the ventricle and the pericardial sac. This is shown in those cases in which the double contour was visible (as in my cases), due to a decrease in the space which separated both contours during Müller's test. This is more clearly observed at the left border of the heart when the left ventricle is hypertrophied, inasmuch as the left ventricle increases its volume more than the right and pushes the liquid toward other parts of the pericardial cavity. If the right ventricle is the more hypertrophied, this would be the chamber which would dilate more during this test, and it would be the one to push the pericardial fluid toward the region of the left border, against the left ventricle. Under those conditions, there will be observed an increase in the space which separates the double contour instead of the decrease during Müller's test, but in the inferior part of the right border of the heart the phenomenon is more evident during Valsalva's test.

SUMMARY

Kymograms made during Valsalva's and during Müller's procedures are very useful in the interpretation of the ordinary kymograms obtained during respiratory rest.

They permit the determination of alterations of the waves due to the presence of small pericardial effusions which otherwise may pass unnoticed. The changes of the form of the waves are very important in the cases of combined valvular affection, infarcts of the myocardium, congenital anomalies of the heart, and cavities in communication with the cardiac chambers.

The variations of the transverse diameter of the heart, measured in a relative manner gives information concerning the existence of abnormal post-systolic residues and the capacity for adaption of the ventricular myocardium in acute overloaded states.

The author wishes to thank Professor Justo Montes Pareja for his suggestions in the course of the investigations, as well as the personnel of the cardiac clinic of which he is Professor, for their help in the clinical study of many of the cases.

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RATIONAL RADIOTHERAPY[1]

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ALTHOUGH some forty years have passed since x-rays were found to have a beneficial effect in the treatment of cancer, the sum total of definite and accurate information regarding this treatment is surprisingly small. As a matter of fact, the one thing about which there seems to be no disagreement, namely, the effect of the rays in skin malignancy, was discovered almost at once and there has been no fundamental alteration or addition of opinion regarding this particular condition since.

As early as 1902, when Pusey and Caldwell published their textbook on the roentgen rays, many cases of cancer of the skin were being treated and cured by this agent.

It is true that many refinements of technic which have resulted from the accumulated experience of subsequent years were unknown at that early period. However, the fundamental principle which underlies this type of treatment was no different at that time than it is now.

I refer to the use of radiation as a destructive agent. In skin lesions such a method of application is entirely practical. It is only necessary to know the amount of radiation required to destroy the involved tissues and to apply that dosage where it is needed, protecting surrounding normal tissues with lead. The normal structures beneath the lesion will not be destroyed because they do not receive as large a dose of rays as the diseased tissues above them. In this instance, the factor of tissue absorption and the inverse square law are both working favorably.

If the diseased area is situated beneath the surface of the body with normal tissues above and around it, both these factors are working unfavorably.

It is for this reason that the treatment of superficial lesions and of deep lesions are two entirely different problems.

In the treatment of superficial malignancy, it is only necessary to apply an escharotic dose to the involved area which then sloughs away, and in the vast majority of cases the resultant ulcer heals in by granulation. But such a system of treatment is obviously impossible when the cancer is situated inside the body.

If we accept this fact and forget entirely our experience in treating superficial lesions when we come to deal with deep-seated ones, I believe our progress in treating the latter type of case will be much faster.

The first, and apparently insurmountable, obstacle we meet when we attempt to treat deep-seated cancer by the destructive-dose method, is the fact that the lethal dose for most types of cancer cells is little different from that required to destroy normal cells. When treating superficial lesions, the destruction of a few normal cells around or beneath an epithelioma is a matter of little moment. However, if one is treating a carcinoma of the bladder, for instance, it is hardly practical to produce a sloughing of all the normal tissues in the region of the lesion in order to bring about a like effect on the cancer.

In practice, it has been found that the amount of radiation required to destroy an epithelioma of the skin, if applied so that the effect of all the treatment given is manifested at one time, is from seven to ten times a skin erythema dose, or about 6,000 roentgen units measured in air. If this dosage is applied to any normal tissues in a similar manner, it will produce sloughing.

I have reason to believe that this dosage is in reality a lethal dose for all types of cancer, both superficial and deep-seated. However, it is lethal only if applied so as

[1] This is one of a series of papers contributed by friends and former pupils of I. Seth Hirsch, M.D.

to be effective all at one time; not necessarily a single dose, but a single-dose effect.

This is very different from the theory advanced at about the time when 200,000-volt treatment apparatus came into general use. Those who were practising radiotherapy at that time will recall that 120 per cent of a skin erythema dose applied to the cancer was regarded as sufficient to destroy the lesion. This theory was not in accord with the experience of many who had been treating cancer for years, but it was generally accepted at that time. Treatment of deep-seated cancer was carried out on this basis for about ten years before it became generally accepted that this method was based on a false premise. As a matter of fact, this dosage is essentially all that normal intra-abdominal tissues will stand without injury if applied to produce a single effect. We know that the lethal cancer dose is about eight times as much as this. It is, therefore, obvious that no single-effect method of treatment can be successful in treating abdominal carcinoma.

I stress this because there has been a tendency lately to apply the Coutard method of treatment to all types of deep-seated malignancy. The Coutard method is a single-effect method of treatment, calculated to produce tissue destruction in exactly the same manner as we have been doing successfully in superficial malignancy for many years.

It is applicable in cancer of the larynx, mouth, or any region where sloughing of normal tissues around the lesion will not do any serious harm. It cannot be carried out in the same way in intra-abdominal lesions for obvious reasons, as I have already explained.

However, simply because an escharotic dose cannot be applied to intra-abdominal lesions does not necessarily imply that these lesions cannot be influenced, or perhaps even destroyed by radiation.

In considering this problem, it will be helpful to study the effect of treatment in locations that are readily observed, for instance, a subcutaneous malignant nodule in the chest wall, recurrent after amputation for cancer of the breast, or a metastatic gland in the axilla or supraclavicular region, or cervical metastases in cancer of the mouth. These are all cancerous lesions of a virulent type and are particularly difficult to handle because metastatic and recurrent lesions are more resistant to radiation than a primary one. Yet, everyone knows that these lesions can often be made to disappear entirely by properly applied radiation and without producing sloughing of the tissues, as is done in treating superficial lesions, or by the Coutard technic.

Certainly, small subcutaneous lesions can be treated by the single-effect method and using an escharotic dose if one so desires, but there is no advantage in doing so. If the mass is quite large, it is doubtful if it can be completely eliminated by any single-dose method that has been used up to this time. It seems evident, therefore, that although cancer cells and normal cells are destroyed by approximately the same amount of radiation if applied to produce a single effect, repeated smaller doses may bring about an entirely different effect.

A possible explanation of this phenomenon may be that normal cells recover more thoroughly, or more quickly, or in some other different manner from malignant cells. It would be extremely helpful if we knew the exact nature of this difference. Until this information is available, it would seem sensible to try to apply our knowledge regarding the treatment of visible subcutaneous lesions to those that are more deeply seated.

Our methods of measuring depth dose are now sufficiently accurate that it should be possible to apply the same dose to a cancer of the bladder as has been found adequate in a metastatic cervical node, for instance. It is true that the cervical node may be destroyed by methods that vary widely and some of these might not be applicable to intra-abdominal lesions. Conversely, it is my belief that a method which will not destroy the cervical node will be equally unsuccessful in cancer of the bladder.

In the author's experience, a funda-

mental principle underlying a fractionated dose technic is that an atrophic effect must be established with the beginning of the treatment, and subsequent treatments must be close enough together and of sufficient intensity to keep up this effect. If the initial dose is too small, or if the succeeding doses are too small or too far apart, instead of producing the desired destruction, the tissues develop a resistance to radiation which entirely defeats the purpose of the treatment. In recent literature I believe too much emphasis is being placed on total dose rather than method of administration.

I saw a woman a short time ago who had had her breast removed for carcinoma and some time later developed metastases to the bones of the pelvis. She was treated over the pelvis with x-ray therapy, using modern apparatus of 200,000-volt capacity. As reported to me, she received a total dose of 8,000 r units over the pelvis. Within a year she conceived and later bore healthy twins, although at the time of labor the pelvic bones and one femur were riddled with metastatic lesions.

It would seem evident to the most casual observer that a dosage of radiation, regardless of how many r units were applied, that would not sterilize a woman would have little effect on cancerous tissue. David R. Bowen used to say that the successful treatment of cancer depended on putting the cancer on the run as quickly as possible and keeping it that way. I agree with this general principle.

Undoubtedly there is a minimum dosage below which no beneficial results can be expected. Those who treated deep-seated cancer with x-ray therapy before the invention of the Coolidge tube, know this only too well. It should not be necessary to repeat the experience of those years.

Probably the revival of the method of frequently repeated small doses depends on the very successful Coutard technic. This, however, it must be remembered is simply a protracted single-dose effect and is applicable only to lesions that can be cured by a single dose. For other lesions, a method is necessary which will produce an injurious effect on both normal and cancer cells, and the interval between treatments should be such that normal cells will recover more fully than the cancerous cells. By a repetition of treatment the cancer will finally be entirely destroyed without too serious damage to normal tissue. Such a technic may be impossible of achievement, but with our present knowledge it seems the only way in which deep-seated cancer may be eradicated. Until now, no quality of radiation has been discovered which has a greater effect on cancer cells than on normal cells, although this is always possible and, if consummated, would alter the entire outlook of radiotherapy.

I am not certain that it is desirable to devise a technic whereby there is no systemic reaction to the treatment. I believe radiation sickness is the direct result of the action of the rays on the tissues. If this be true, a method of administration that produces no reaction, produces only a negligible effect upon the cancer. Consequently, one large dose should have more beneficial effect than the same amount divided into two or three doses.

I have no proof for this statement except experience, and I may be interpreting this experience wrongly, but I am convinced that there is a minimum dose below which treatment is ineffective. This dose is probably not the same for different types of malignancy, or for different individuals.

Probably it would be unwise to attempt to set an arbitrary figure for this dosage at this time, but every radiotherapist should realize very definitely that the subdivision of dosage may have an effect entirely different from that intended.

The other factor which has such an important bearing on the effect produced is the interval between treatments. If it be true that cancer cells and normal cells are affected in about the same manner by a given dosage of x-ray therapy, but that normal cells recover from this effect more quickly and more thoroughly, then it should be theoretically possible to cause destruction of cancer by repeated doses

without producing death of normal cells subjected to the same dosage.

However, in following out such a theory, it is readily seen that the interval between treatments is of paramount importance. Certainly not enough experimental work has been done on this factor. The only complete technic worked out on this basis is that of Coutard, which is a single-effect method and, to my mind, not desirable in many conditions. By this I mean that many cancerous lesions will respond better if given larger individual doses than are used in the Coutard technic, and at longer intervals than the customary daily treatment.

In treating intra-abdominal lesions, one is greatly handicapped by being unable to observe the effect of the treatment. Occasionally, undesirable effects are demonstrated at operation or autopsy, but this does not help much except as a warning of what not to do.

Naturally, there is no substitute for calculating the depth dose on various intra-abdominal organs before a projected series of treatments is given. If this is accurately calculated by any accepted method and the effect of the treatment on the bladder mucosa noted by frequent cystoscopic examinations, one can obtain a very reasonable idea of what is actually being done to abdominal organs by the technic in use.

I do not believe one can hope to destroy cancer with any dosage which does not produce inflammation and edema of the bladder mucosa, and not by one dose of this quantity. However, if this dosage can be given accurately, it can be repeated several times at appropriate intervals. I have seen carcinoma of the bladder disappear entirely following treatment carried out in this manner.

Although x-ray apparatus and measuring devices are now developed to the point at which any given dose can be accurately applied, unfortunately, it is still not possible to prescribe a standard course of treatment which can be depended upon to produce a desired effect. This is partly due to the fact that malignant lesions of different types respond differently, and, more particularly, to the location of the lesion, which may alter the effect tremendously. However, more important than any of these is the individual himself. We may or may not believe that an individual has a systemic resistance to cancer, but certainly no one having considerable experience in the treatment of cancer with radiation doubts that there is a wide variation in the reaction of patients to identical treatment. For this reason, there is no substitute for judgment and skill on the part of the radiotherapist in adapting the treatment to the individual case.

CYSTIC DISEASE OF THE LUNG[1]

By L. R. SANTE, M.D., *St. Louis, Missouri*

SINCE the report of Koontz, in 1925, of 108 cases of cyst of the lung collected from the literature, our knowledge of this subject has been enhanced by the reports of many additional cases. By 1937, the number of reported cases had reached 381, as collected by Schenck. It is quite probable that some of these cases were reported as cysts without adequate proof of their true cystic character, but it is also true that many other cases have been observed which have not been reported. At any rate, the condition is much less uncommon than it was previously thought to be.

No attempt will be made to review the literature in detail: references will merely be made to specific cases or reports pertinent to the discussion; the reports of numerous interesting cases are contained in the bibliography. For a clinical review of the literature the reader is referred to King and Harris, Wood, and Maddox; for a review of the pathologic findings to Chodkowska; for a discussion of the mechanism of formation to Mueller, Dubrow, and Anspach and Wolman; for differential diagnosis to Anspach and Wolman, Peirce and Dirkse.

At first, the air cyst was observed with its tendency in certain instances to assume expansile type; then the fluid cyst was seen with discharge of its contents and replacement by air, thus establishing the connection between the two types. It was assumed by some that all *cysts* were congenital and that all went through these same stages. Now it has been recently shown (Peirce and Dirkse) that the same series of events can take place in a previously healthy individual with ultimate complete recovery.

Since it is thus established that the manifestations of cystic disease of the lung may be either congenital or acquired, it at once becomes evident that the condition is produced as a result of certain mechanical forces which operate in response to certain structural changes in the lung, regardless of whether these changes occur from developmental defect or acquired disease. Might it not be well, therefore, to direct our attention to the character of these changes and consider how they may be brought about, since only by a thorough knowledge of their operation can the condition be intelligently treated.

First of all, let us consider out terminology. Let us apply the term *congenital* only to those cases in which there is absolute proof of the congenital origin of the lesion.

Let us limit the term *cyst* to confined collections of fluid within the lung. If we consider a cyst in the general sense as, "any sac or dilated space, normal or abnormal," then the term cyst could be applied to any space in the body; but if we consider a cyst in the commonly accepted sense, as an abnormal sac resulting from partial or complete occlusion of a secretory glandular structure, then, obviously, the air-filled cavities do not fulfill these conditions.

Let us refer to air-filled cavities as *pneumatoceles*, as suggested by Peirce and Dirkse, with certain qualifications as to their size, location, or behavior, as, for instance, "large solitary pneumatocele," or "expansile pneumatocele," or multiple "emphysematous pneumatocele," or multiple "bronchiectatic pneumatoceles."

Having defined our terms, let us proceed to the consideration of various types of lesion referred to as *cystic disease*. One of the most common types is seen as multiple thin-walled pneumatoceles, clustering about the larger bronchial branches in the hilum regions and adjacent areas, giving

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rise to the condition referred to as *cystic bronchiectasis* (Fig. 1-*D*). When the cavities are small and their walls are thick the term *honeycomb* (Chodowska) has been applied to their appearance. This type of involvement is well illustrated by the following cases.

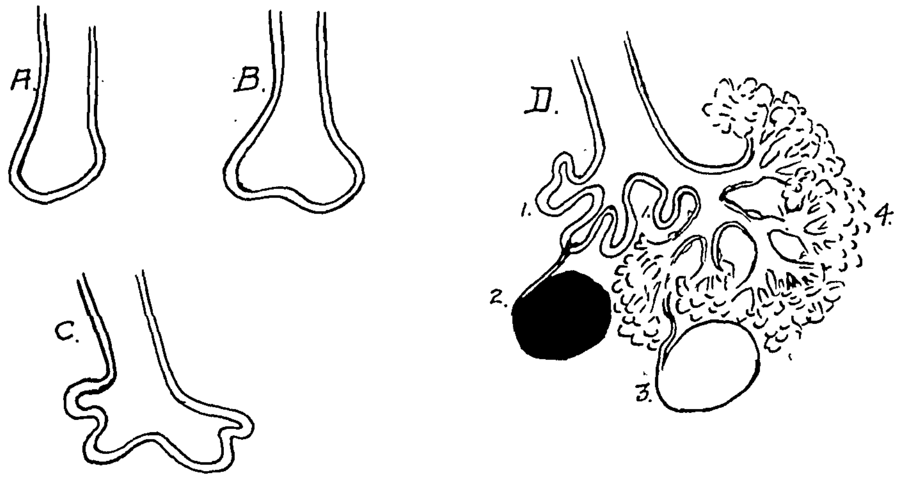


Fig. 1. Schematic drawing showing production of anomalies during development of lung structure, as suggested by Mueller, King and Harris, and Dubrow. (*a*) The lung develops from evaginations of the larger bronchial branches. (*b*) These show enlargement of the advancing end of the pouch with indentation or folding of the end of the sac which leads to division of the bronchus. (*c*) Subsequent divisions and subdivisions continue in this manner. Ultimately this process leads to the complete development of normal lung structure as shown in *d*-4. (*d*) Mal-development of the lung may occur at any point in its development. (1) It may be arrested at the larger bronchial branches giving rise to multiple small pneumatoceles—congenital bronchiectatic type. (2) Its growth may be suspended for a time, only to start in again, resulting in complete or partial atresia. Subsequent secretion of the lining membrane may produce a fluid cyst. This may later empty into the bronchus and refill with air. If a check-valve is formed, the pneumatocele may expand to large proportions. (3) The anomalous development may occur in the terminal air structure beyond the point of mucus secretion, resulting in large pneumatoceles.

Case 1 (Figs. 2 and 3-*A* and 3-*B*). Colored male, aged 62 years, was sent in for x-ray examination of the chest from the out-patient department, on Feb. 11, 1937, because of a history of occasional chest pains and dry non-productive cough. There was no history of hymoptysis.

The past history disclosed the following diseases without complications; pertussis at 16 years of age, measles at 18 years of age, and pneumonia at 59 years of age. He thought that he had had influenza, in 1918, during the epidemic, but was not sufficiently sick to be confined to bed. Only small quantities of mucoid material were expectorated but reported sputum examinations were always negative for tubercle bacilli. The temperature, pulse, and respiration were normal.

X-ray examination of the chest revealed multiple, thin-walled cavities clustered about the hilum regions and in both lower lobes. There was no infiltration or consolidation in either lung and no evidence of other parenchymatous pathology. Intratracheal injection of iodized oil showed that all of these rounded cavities communicated directly with the larger bronchial branches and that the cavities themselves were merely the rounded ends of blind pouch-like evaginations from them. These pouches did not contain any detectable amount of secretion and there was no evidence of any inflammatory reaction in the surrounding tissues. While the picture was typically one of bronchiectasis, there were no clinical signs for support of such a diagnosis. Observation more than a year later revealed little, if any, change

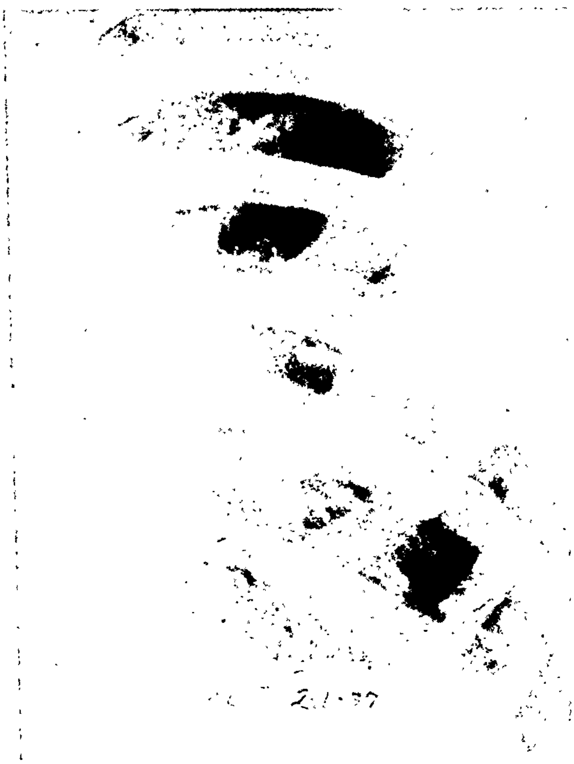


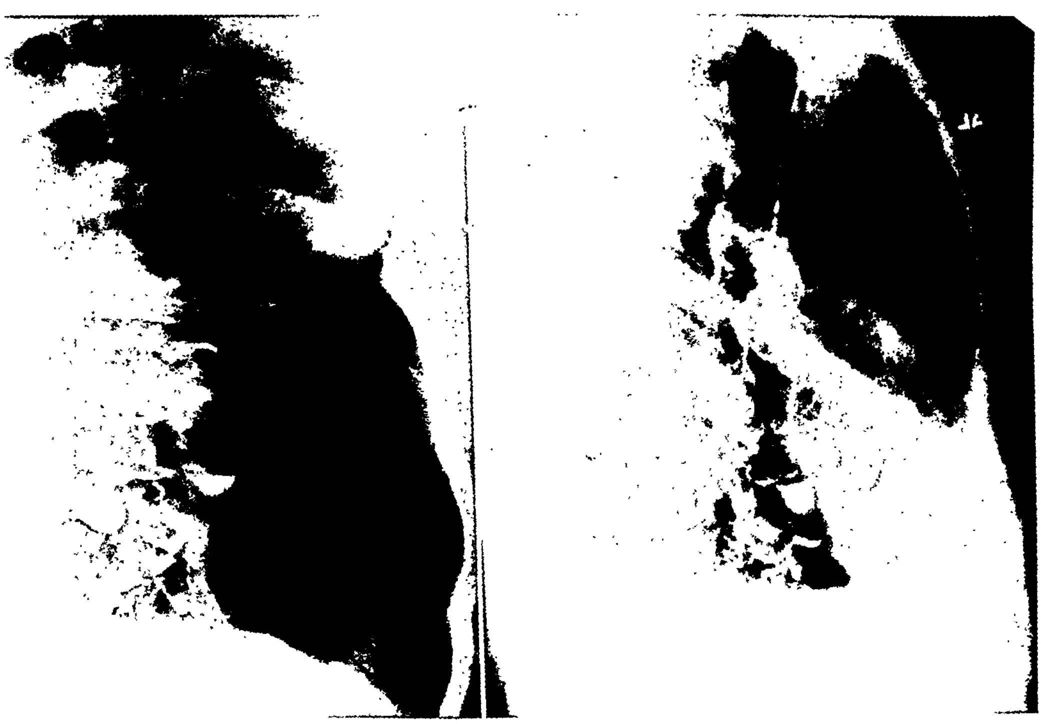
Fig. 2. Case 1. Numerous ring-like shadows about both hilum regions showing no change over a considerable period of time, without symptoms of infection.

in the condition and still showed no evidence of infection.

Case 2 (Figs. 4 and 5). H. I., white female, 29 years of age, entered the hospital on Dec. 9, 1935, with the chief complaint of headache. She had had the usual childhood diseases without complications. She denied any previous cough or expectoration, except for occasional head colds from which she always recovered promptly. Within the last few years she had had attacks of precordial pain which caused her to sit up in bed, but this she attributed to her high blood pressure.

She had always enjoyed good health, up to three months prior to admission. At that time she experienced a sudden hemoptysis of about two teacupfuls of blood without other symptoms. She had never had hemoptysis before nor has there been any since this period. This attack was not accompanied by fever or any other sign of illness.

Sputum examinations of scanty specimens on several occasions failed to reveal tubercle bacilli. The urine was essentially



A B

Figs. 3-A and B. Case 1. After intratracheal injection of iodized oil, these were seen to be dilated air-filled sacs communicating by large openings with the larger bronchial branches. These areas may be characterized as multiple pneumatoceles of congenital bronchiectatic origin.

negative, as was the Wassermann test. Her blood pressure was 168/104. Pulse rate, respiration, and temperature were normal.

X-ray examination of the chest at this time showed numerous ring-like shadows along the entire mediastinal border of the left lung. There was no infiltration or consolidation in either lung and no other indication of pathology. There was no detectable secretion in the sacs and no evidence of surrounding inflammation. Iodized oil injection showed free communication of these larger cavities of the larger bronchi on the left side in rather orderly arrangement. In view of the lack of evidence of infection over a considerable period of observation, the condition must be considered as multiple pneumatoceles of bronchogenic origin or *congenital bronchiectasis*.

Case 3 (Fig. 6). L. L., white female, aged 57 years, entered the hospital on April 26, 1937, for an old fracture of the femur. She gave a history of having had the usual childhood diseases but denied any complications. She had suffered from chronic non-productive cough and periodic attacks of dyspnea for a long time but had never had large amounts of expectoration nor signs of infection. There was no hemoptysis. The Wassermann and urine tests were essentially negative.

X-ray examination of the chest showed multiple small *cyst*-like cavities in the upper third of the right lung. The walls were thicker than those of the previous case, giving rise to a honeycomb appearance. There was no change in appearance over the entire period of observation and no evidence of other disease.

Another illustration of this type of involvement was described by the author, in 1929 (Sante, 28–1). In another instance encountered in 1921 a diagnosis of chronic diffuse interstitial fibrosis with

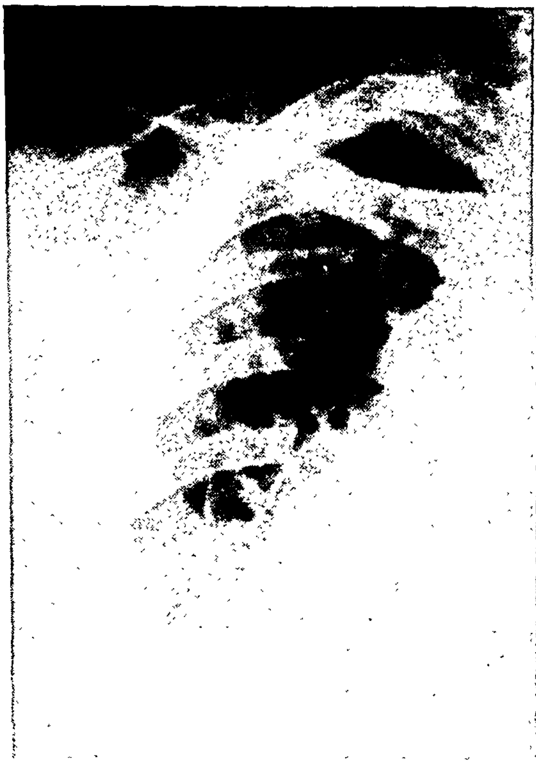


Fig. 4.

Fig. 5.

Fig. 4. Case 2. Multiple rounded ring-like shadows on the right side in the hilum region in a woman 29 years of age, discovered incidental to a general examination. No symptoms of pulmonary infection.

Fig. 5. Case 2. Intratracheal injection revealed these to be large air-filled pouches connected by large openings to the larger bronchial branches in rather orderly arrangement. These might be spoken of as multiple bronchiectatic pneumatoceles or congenital bronchiectasis.

cavity formation was made (Sante, 28–2). Multiple ring-like shadows were present throughout one entire lung of an 18-month-old child. There was no adequate explanation for these air spaces and it was

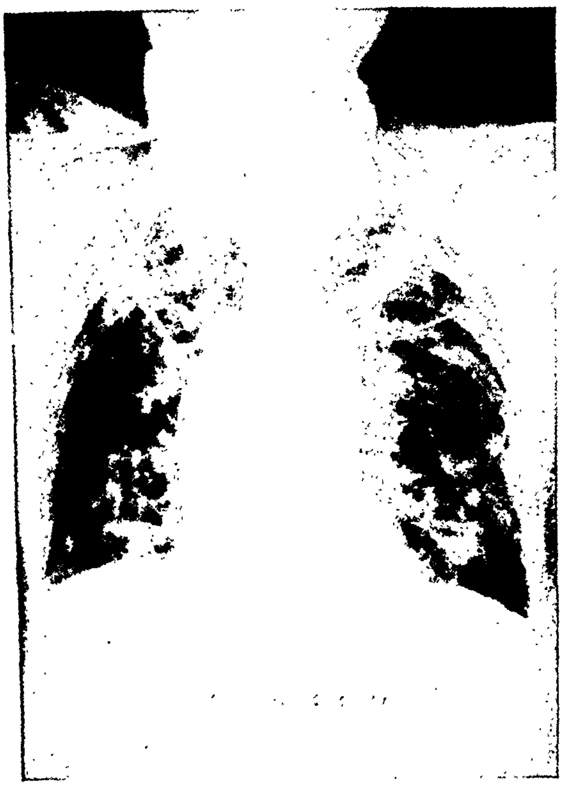


Fig. 6. Case 3. Similar type multiple pneumatoceles in the hilum region of small size with thicker walls, producing the appearance characterized as "honeycombed."

assumed that they were secondary to chronic interstitial fibrosis of the lung. There was no change over an extended period of hospitalization. In view of our present knowledge, I feel sure that this was a case of congenital *cystic* disease of the lungs.

Consideration of the possible method of development of such conditions leads us to the following speculation (Mueller). During embryological development (Fig. 1), the lung structure develops from bronchial buds growing outward from the larger bronchial branches. Should a group of these pouch-like outgrowths become arrested in their growth and not continue in their natural development, a condition would arise essentially similar to that seen in these cases. As long as infection does not occur, such patients might go on for years, even into adult life, without any manifestation of their presence. The walls of these cavities are relatively strong and resistant, being composed of elements of bronchial structure often containing cartilage. They maintain a wide open communication with the larger bronchi and air enters and leaves readily with each respiration. They have a mucous membrane lining. If it were not for their rigid walls they would completely collapse and refill during each respiratory cycle.

Pneumatoceles of this type are rarely seen at the periphery of the lung; they are not associated with interstitial fibrosis. If infection occurs, the condition becomes essentially the same as bronchiectasis and must be regarded as such. Whether or not all cases of bronchiectasis have their origin in this manner, subsequently becoming infected, it is impossible to say, but there is ample indication that bronchiectasis can also be acquired from the effects of chronic inflammation. Chronic nasal sinus or other infection resulting in fibrosis and destruction of the peripheral structures may leave only blind bronchial pouches.

The next type of lesion for consideration is the *fluid cyst*, which seems to conform more closely to our conception of a true cyst. That congenital fluid cysts of the lung really occur, there can be no doubt, since instances are on record in which such epithelium-lined sacs have been present at birth. There are, however, relatively few proven cases of fluid cysts in adults. Fluid cysts appear roentgenographically as rounded areas of increased density, frequently central near the hilum region but they may occur at any location in the lung. In some cases the fluid sac may be elongated in the region of the interlobar septum, taking on the appearance of an interlobar effusion. These areas may show little change over long periods of time and it is this persistence of the lesion without evidence of inflammation or infection which

is a very important point in the diagnosis. Yet this is by no means characteristic since we have seen localized encapsulated empyema and even lung abscesses so completely walled off by fibrous tissue that they showed no change over a period of years and gave no manifestation of infection. At this stage, lung cysts may resemble newgrowths; usually, however, newgrowths show some progressive enlargement. After a time, fluid cysts usually discharge their contents in whole or in part into the bronchial system. This is likewise a potent but by no means an absolute factor in the diagnosis. A localized pleural effusion may rupture into a bronchus and intermittently discharge its contents, producing a pleural vomica. Likewise, if the localized effusion is in the interlobar space it may even give rise to an appearance of being within the lung. If the fluid be of mucoid nature and not purulent, this is also a favorable point in the diagnosis of a true cyst. In some instances the sac remains partly filled with air after intermittent discharge of the fluid contents; in others, the fluid is completely evacuated never to return and the sac becomes filled with air, giving rise to a pneumatocele.

A B

Figs. 7-*A* and *B* (*above*). Case 4. A rounded, well-defined shadow in the left hilum region which appeared during an acute inflammatory process in the chest and remained unchanged for several weeks. *A*, anterior view; *B*, lateral view.

Figs. 8-*A* and *B* (*below*). Case 4. Discharge of fluid content into a bronchus disclosed the fluid character of the lesion and eliminated possibility of newgrowth. The patient was operated on for empyema and made complete recovery. A pleural vomica of this sort could easily be mistaken for fluid cyst. *A*, anterior view; *B*, lateral view.

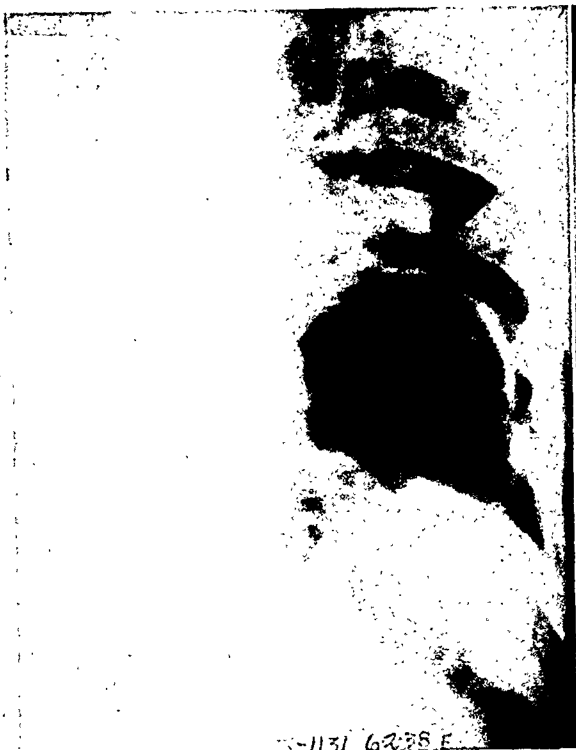
Certain discrepancies which may arise in the diagnosis of a fluid cyst are well illustrated by the following cases.

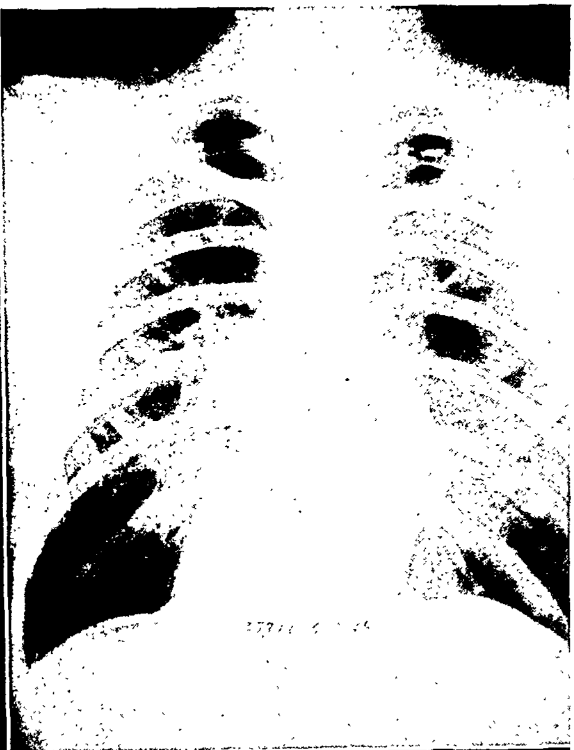
cavity with secretory epithelium which results in a fluid cyst. This error in growth would have to occur in a smaller bronchiole, nearer the periphery, yet one having a sufficiently muscular coat and elastic fibers to permit expansion, but still retaining a mucous membrane lining. The cyst continues to enlarge until the pressure of its contents inhibits further secretion from its membrane. Rupture of the cyst into a bronchiole may result in complete evacuation of the cyst. The forces which tend to raise the pressure within the cyst are the tension of the elastic cyst capsule and the pressure of the surrounding normal lung structure. These, then, are the forces which tend to cause evacuation of the cyst after it ruptures. Evacuation may be either through a large opening which permits permanent collapse of the cavity and cure, or through a smaller opening which still remains patent.

Once collapsed, why should the sac again fill with air acting against the pressure of surrounding lung structure which still remains as a potent force resisting re-expansion? The factors concerned in subsequent inflation of the sac are the ratio of resistance of the cavity wall to the resistance of the normal alveolar structure supplied by a bronchiole of similar size. If the opening permits free passage of air on inspiration and expiration, then obviously air should enter more freely than it would into the adjoining alveolar structure since the flail cavity wall offers little resistance to inflation. The forces of deflation exerted on the cavity would be less pronounced, since it would not be subjected to the force of elastic recoil of its walls until inflation had re-filled the cavity with air up to a size almost equal to that of the original fluid cyst. At this point, any further air gained on inspiration should be lost on expiration and a definite interchange of air should be established equal to that of an equivalent amount of lung tissue. Such a small amount of change might be difficult to see during respiration, but it should not be so great that on expiration there would be evident displacement of the heart and mediastinal structure to the opposite side. The air in the cavity should never exceed atmospheric pressure, since it enters passively from the outside. When such a condition is seen in which the heart and mediastinal structures are displaced to the opposite side *on expiration* from pressure of a pneumatocele, but return to normal position *on inspiration*, it implies a simple check-valve at the inlet of the cavity. Since the act of inspiration is passive, a simple check-valve might retain the pressure in a pneumatocele at atmospheric pressure during expiration causing displacement of the mediastinal structures, but should not continue to cause expansion. This results in a *non-expanding pneumatocele*, varying only slightly with respiration without causing displacement of the mediastinal structures at height of inspiration. In certain cases, pneumatoceles may continue to expand. Cases have been reported in which the pressure developed in these pneumatoceles was sufficient to cause herniation through the mediastinum into the opposite pleural cavity (King and Harris). Death has resulted in a number of instances from such uncontrollable expansion. Obviously, a single check-valve will not explain the extreme degree of pressure sometimes obtained. Expanding pneumatoceles of this type have been referred to as *balloon cysts*.

The mechanism by which such excessive pressure is developed is difficult to understand. It may be due to the presence of an accessory air chamber acting as a vestibule to the main pneumatocele, so arranged that the movement of the chest wall during respiration exerts an additional force beside that of atmospheric pressure which might act as a pump, filling the cavity. It would seem obvious that to secure such high pressure it would be necessary for some additional force to be expended beside the passive equalization of air pressure.

Even this sequence of events in itself may conceivably be simulated by a localized pleural effusion rupturing into a bronchus with formation of a check-valve





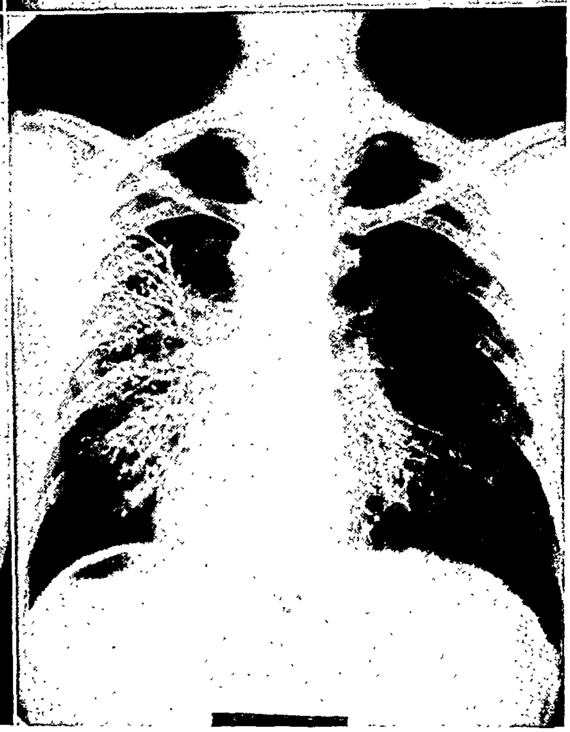


Fig. 13 (*upper left*). Case 7. A large rounded, thin-walled pneumatocele about ten centimeters in diameter in the left pleural cavity, just above the diaphragm and posterior to the heart. The history indicated that this had been present for over ten years.

Figs. 14-*A* (*upper right*) and *B* (*lower left*). Case 8. Large pneumatoceles occupying the upper portion of both lungs. *A*, anterior view, in which the lung markings are absent from these regions but the walls of the air sacs cannot be visualized. *B*, lateral view shows clearly the limiting wall of the pneumatocele.

Fig. 15 (*lower right*). Case 8. On intratracheal injection, iodized oil fails to extend into this portion of the lung.

mechanism of similar nature. There is no reason why such a condition could not occur, and, if the original sac were produced by the interlobar pleura, the resulting pneumatocele would appear to be within the lung even if pneumothorax were induced as a diagnostic procedure. An air sac may begin to expand at any time, and varying types of valve mechanism may be present. At any rate, it may be assured that any air sac which remains absolutely the same during inspiration and expiration must have some type of check-valve. This type is well illustrated by the following case.

Case 6 (Figs. 11 and 12). A. G., white male infant, one year of age, entered the hospital on Feb. 20, 1936, with an upper respiratory infection. There was a history of cough all winter, with acute illness starting three days prior to entrance into hospital, with chill, fever, and pain in left ear. Nothing in the past history seemed of significance. Birth was normal, respiration spontaneous, weight seven pounds three ounces at birth. There were no convulsions. Subsequent developmental history was normal; there was no history of previous contagious disease.

Examination at this time disclosed adenoids and bilateral otitis media. The temperature was 103° on admission. There were no symptoms referable to the chest at this time or at any time during the child's life. Routine x-ray examination revealed a large rounded air space on the right side, devoid of lung markings, almost filling the pleural cavity. There was no indication of change in size of the air sac during respiration. Repeated examinations for several months showed no change and the child experienced no distress.

Similar solitary pneumatoceles are sometimes seen in adults, as is illustrated by the following instance.

Case 7 (Fig. 13). S. L. D., white male, aged 43 years, entered the hospital on June 2, 1938, complaining of diarrhea and weakness. His symptoms dated from 1928, when he had an attack of "intestinal flu" and colitis. Has not been able to work since that time. In 1930, he had a paratyphoid infection and was sick for three or four weeks. In 1930 and 1931, he had amebic dysentery. *In 1929, on x-ray examination, he was told that he had a cyst in his lung.* Temperature, pulse, and respiration were normal. Blood and urine examinations were essentially negative. The sputum was negative for tubercle bacilli. X-ray examination of the chest made June 2, 1938, revealed a rounded thin-walled pneumatocele, fully 10 cm. in diameter, occupying the left pleural cavity posterior to the heart. At no time during the period of observation did it contain fluid and there was no evidence of other pathology in either lung. The size of the cavity did not change during respiration and there was no change in appearance at any examination. There were no symptoms referable to the chest and the condition was discovered on routine examination.

On intratracheal injection, lipiodol does not enter the devious pathways into the air cavity in such types and would no longer seem to be indicated as a diagnostic procedure under such conditions. Inspiration and expiration films will demonstrate the lack of expansion of the lesions and indicate at once the check-valve type of the condition; whenever this is established, lipiodol injection into the lung would no longer seem necessary. Some observers feel that rupture of a fluid cyst precedes the development of all air-containing pouches or pneumatoceles, but there does not seem to be any logical reason why a check-valve type of opening must be made by rupture of a fluid cyst and could not be the direct result of congenital mal-development, inflating primarily with air at the time of birth.

Pneumatoceles which arise from the peripheral lung structure are usually large, having extremely thin walls; they are often multiple, and are not infrequently bilateral. As far as I have been able to find, they are not preceded by fluid cysts and do not have a secretory lining membrane. They occur frequently in adults and their site of involvement is often in the upper lobes. The limiting membrane

may be invisible in the postero-anterior view, giving rise to a loss of lung markings in the area of involvement not unlike the appearance of pneumothorax, but in the lateral view the limiting membrane is as a rule clearly visible in such cases. Absence of collapse of the lung elsewhere is indication of the true nature of the disease.

Pneumatoceles of this sort constitute the bullous form of emphysema, they may show no change for long periods of time, or they may show continuous progression, almost completely replacing the lung structure.

Case 8 (Figs. 14-*A*, 14-*B*, and 15). E. S., white male, aged 31 years, entered the hospital on Feb. 26, 1936, with the complaint of loss of weight, restlessness, and cough. He gave a history of the usual childhood diseases without complications. He had no unusual respiratory disease except a chronic dry non-productive cough for the past year. He had contracted syphilis, in 1923, and his Wassermann test at this time was 4 plus. No fever or other indication of infection was present. His blood pressure was 125/85. He had been well, until two months before entrance into hospital, when he began to lose weight; he lost 15 pounds in two months.

X-ray examination of the chest on Feb. 26, 1936, revealed lack of lung markings throughout the upper portions of both lungs. On lateral view examination these areas seemed to be bounded by thin membranes. There was no evidence of inflammatory process in either lung and no indication of pneumothorax.

Further x-ray examination on April 15, 1936, after the intratracheal instillation of lipiodol, revealed normal bronchial structure throughout but failed to reveal any free communication of these areas with the bronchial structures.

That the pneumatoceles in this type of involvement do have bronchial connections there can be no doubt, otherwise they could not maintain their air contents. The process in this instance is probably similar to that already described, with check-valve permitting air to enter but not to leave the air sacs produced by the tortuous tiny air passages. These are so small that lipiodol cannot enter.

They may occur from congenital defects in the elastic structure of the alveolar walls, causing them to be less resistant to filling on inspiration and less patent than normal in emptying on expiration, due to their lack of normal elastic recoil. When the two forces thus concerned become equalized, the pneumatocele stops enlarging. Cases have been reported in which bullous pneumatoceles of this sort continued to expand until they replaced almost the entire lung space of both pleural cavities (Burke).

Such expanding types of pneumatoceles may also be acquired in association with development of emphysema. Emphysema, wherever it is found, is always associated with interstitial fibrosis. Any condition which interferes with passive expiration requiring muscular effort, whether or not this be from narrowing of the bronchiole as a result of muscular spasm or fibrosis, will have a tendency to produce emphysema. The alveolar walls are delicate membranes, consisting of a single layer of flat epithelial cells permitting intimate exposure of the surrounding capillary plexus to the air. Over-distention of the terminal air sacs results in rupture of these thin-walled septa, thereby permitting still greater enlargement of the terminal air sacs. This, in turn, further reduces the normal elasticity of the cell wall, permitting further expansion. Under certain circumstances, a valve-like action may be produced at the opening of the bronchiole, permitting air to enter but not to leave, pumping up the air space until proper equilibrium is established for these conditions. When this is established, the pneumatocele remains constant, showing no demonstrable change during respiration.

Emphysematous blebs may form in the pleural surface in relatively young healthy individuals. These may at times be demonstrated by lipiodol injection. Correlation of the evidence which we have of the development and behavior of fluid cysts and pneumatoceles of the lung with the me-

ess was altered and the ribs and sternum were treated. Soon thereafter the red count receded to within normal levels and persisted without the administration of further treatments. After about forty hydrazine hydrochloride was administered with rapid fall in the red cell count. Upon admission to the radiation therapy service, intensive doses of x-ray therapy were administered to the spleen, over a period

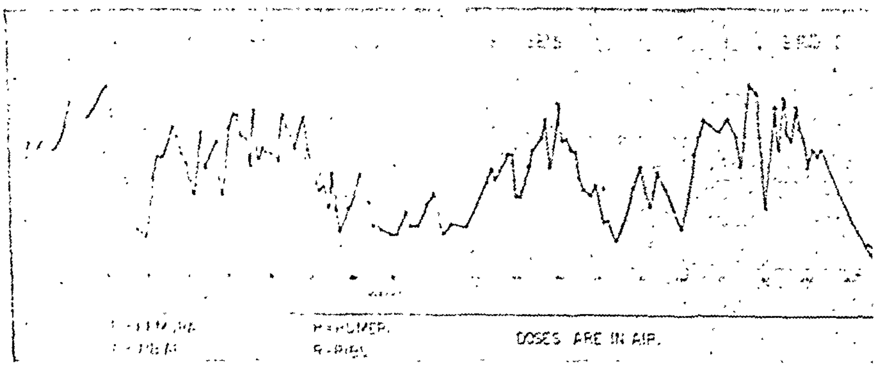


Chart I.

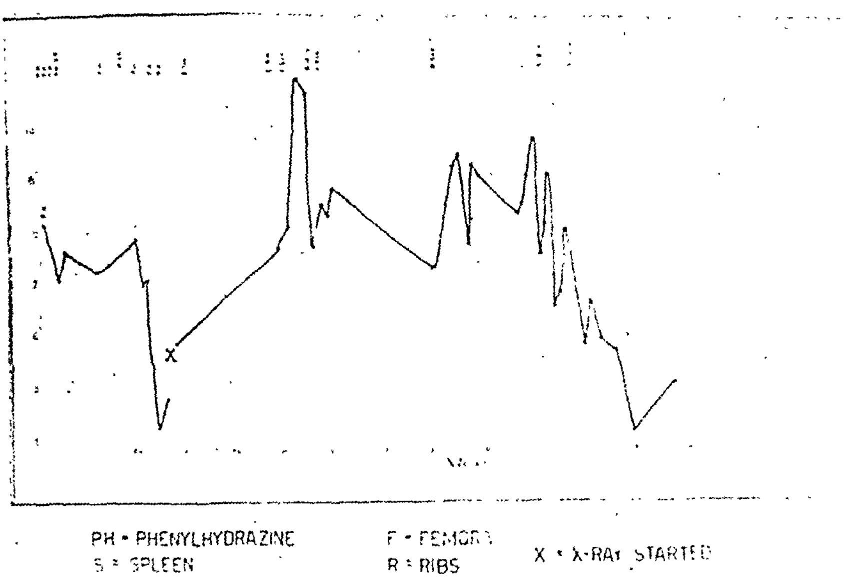


Chart II.

weeks, a new elevation began, at which time treatments were again delivered to the ribs and sternum and were followed by a rapid recession in the red cell level.

As contrasted with the long bones in relation to the ribs and sternum, Chart II compares the nature of response of the spleen with that of the ribs and sternum. During a period of 10 weeks while the patient was on the medical service, phenylof 20 weeks, but, in spite of these doses, the count continued to rise. When the red cell level was at its height, above ten million, the ribs and sternum were irradiated, with rapid and long-lasting response. At the end of 20 weeks, a slight rise was again satisfactorily controlled by irradiating the ribs and sternum. It was interesting to note that the splenomegaly persisted in spite of the fall in the red cells.

It is advisable to curtail treatments when the count begins to show a constant decline; furthermore, the level of the erythrocytes must be judged in relation to the symptomatology. In the absence of any uncomfortable symptoms, treatment need not be administered in the presence of a red cell count of six million, or thereabouts.

Prognosis.—Polycythemia vera, as contrasted to its hemopoietic sisters, the leukemias, need not be considered a fatal disease. C. H., a patient in the series, has been under our observation for eight years and is under satisfactory control. When patient B. G. came to the clinic, his spleen had been enlarged obviously for 12 years. These facts indicate that the disease is well established before symptoms appear. If to that is added the success of control that roentgen therapy can offer, it becomes apparent that these patients live for long periods with the illness. They die usually from cerebral hemorrhage or intercurrent infections at an age that parallels the incidence of the population.

CONCLUSION

Polycythemia vera is an uncommon disease. It may for a time be controlled by phenylhydrazine hydrochloride, but is more satisfactorily controlled by x-ray therapy. The best method is high voltage irradiation administered to the sternum and ribs.

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INTESTINAL MOVEMENTS IN THE ILEOCECAL REGION[1]

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IT is curious that while the intensive x-ray study of the pathology of the alimentary tract has, in the last 30 years, carried the subject from its experimental stage to something that is little short of an exact science, the study of the mechanical physiology, on which the interpretation of the pathology so largely depends, has lagged behind.

Gastric peristalsis was studied radiographically by Kaestle, Rieder, and Rosenthal (9), Cole (4), and Groedel (5) nearly thirty years ago, but at that time x-ray apparatus was feeble and fickle. Great credit is due to these early workers for the success they attained. Few, however, have attempted to unravel the more intricate movements of the food in the small intestine, which is the most important and active section of the alimentary tract as regards digestion. In fact, such a study has come within the region of possibility only since x-ray exposures for this class of work have been reduced to a fraction of a second. From the pylorus to the cecum, therefore, we know very little of the mechanics by which the food is influenced and propelled along its course. In this paper an attempt is made to describe the movements of the terminal ileum, which are clearly much slower and, in consequence, easier to analyze than those of the jejunum, which we hope to study later. I do not know of any systematic investigation of the movements that occur in the ileocecal region. Wingate Todd (12) in his studies only mentioned this section in passing and did not attempt to analyze the movements.

Very early in the days of the opaque meal, Case (3) and Hertz (6) independently described the gastro-ileac reflex, showing that when a patient took food there was a tendency for the terminal ileum to become active and empty its contents into the cecum. Shortly afterward, the writer (2) recorded a counterpart of this link, *i.e.*, the ileo-pyloric reflex: when the terminal ileum was loaded and did not empty into the cecum, food was retained in the stomach, the pylorus being reflexly controlled from the ileocecal region. He maintained that this accounted for the delay in emptying of the stomach that was so frequently noted in association with inflammatory lesions in the region of the ileocecal valve.

Whether there is a definite valve at the junction of the ileum with the cecum is a problem that a number of anatomists and radiologists have studied. Hunter (8) has worked on the anatomical side of the problem and holds that "the lower fold of the frenula coli acts as a valve to prevent the regurgitation of food material from cecum to ileum, and by thus raising the intra-cecal pressure aids in the opening of the ceco-colic sphincter, which in the human subject is incorporated within the frenula coli." He further suggests that "this valve-like action depends on the position of the terminal portion of the ileum; when the ileum ascends from the pelvis along the medial wall of the cecum, the flap acts as a valve, but when it is raised in the 'horse-neck' curve, the valve-like action does not occur. It is in this position that the ileocecal sphincter opens and permits the passage of food from ileum to cecum." Hirsch (7) published a detailed study in which he stated his belief in the existence of a functional valve in this position. Incidentally, he also claimed to have found evidence of a sphincteric tract in the ascending colon, analogous to that found in certain mammalia, but his illustrations are not convincing to me.

[1] This is one of a series of papers contributed by friends and former pupils of I. Seth Hirsch, M.D.

On the surgical side, Kellogg (10) was so sure of the functional importance of the ileocecal valve and of the ill effects of its incompetence, as determined by the backward flow from an enema into the small intestine, that he devised an operation for infolding the terminal ileum into the cecum, thus forming a valvular structure on anatomical lines. My own belief in the importance of this "radiological" incompetence was shattered in one of my first cases, when, although the enema had flowed very freely into the small intestine, at operation, the surgeon, attempting to milk the cecal contents into the ileum, found that nothing could be made to pass back into the ileum. In fact, experience at this and other operations seemed to indicate that it was a matter of chance whether or not the cecal contents could be made to pass back into the ileum.

With extended use of the opaque enema, radiologists found that they could frequently make some of it pass into the small intestine. Weber (11), in his work on this part of the alimentary canal, depends almost entirely on this procedure and succeeds in visualizing the small intestine in a very large proportion of cases. It seems, therefore, that although there may be no definite anatomical sphincter at the termination of the ileum, yet, as in the case of the cardiac orifice, a definite sphincteric action may occur, although it is not a constant feature.

The observations on which this paper is based are drawn from records made with a direct x-ray cinematographic apparatus, built for me some years ago under a grant from the Medical Research Council. This apparatus was designed to take serial radiographs at variable speeds up to eight a second on long bands (100 feet) of x-ray film five inches wide, each picture being five inches square. Many technical difficulties in the operation of this apparatus had to be overcome before satisfactory results were obtained, but the machine is now working well at a rate of up to three radiographs a second, a speed which we hope shortly to be able to double by the use of a contactor that operates more rapidly. The generating plant used in conjunction with this apparatus is a single valve unit, and up to the present time the minimum possible exposure for each radiograph has been one-tenth second. We employ a 10 kw. tube of ordinary type, having a focal spot of 4.1 × 4.1. Under the conditions of our work the exposure to the skin for each radiograph is 1.4 r.

The serial radiographs obtained with this apparatus have been reproduced on 16 mm. film, each radiograph being printed on five successive frames when the originals were made at the rate of three a second, and on eight when they were made at a rate of two a second. Thus, actual speed is reproduced when the 16 mm. film is projected at a rate of 16 frames a second. The movements of the viscera are well shown on the screen and are less jerky than one would expect from this technic. They can also be analyzed on the original films by means of tracings, on which the progress of the contractions of the intestinal walls can readily be followed. In these two ways it is possible to obtain a fairly accurate idea of the mechanics involved.

The subjects of investigation have been laboratory assistants and students, and the time of study has varied with the filling of the cecum. This has ranged from three to four and a half hours after the opaque medium (bismuth carbonate in water) had been given. Use was made of the gastro-ileac reflex in all cases, *i.e.*, a cup of hot tea was drunk either when the subject was positioned or just before, in order to stimulate the movements. Without this it is likely that many of our records would have shown no change in outline, and, in fact, even with this technic, appreciable movement is sometimes absent. Respiratory movements were eliminated as far as possible by compression, and in most cases also the subject held his breath during the period of recording.

In the course of routine work, the radiologist usually palpates the cecum and terminal ileum, but it is seldom that anything in the nature of definite peristalsis

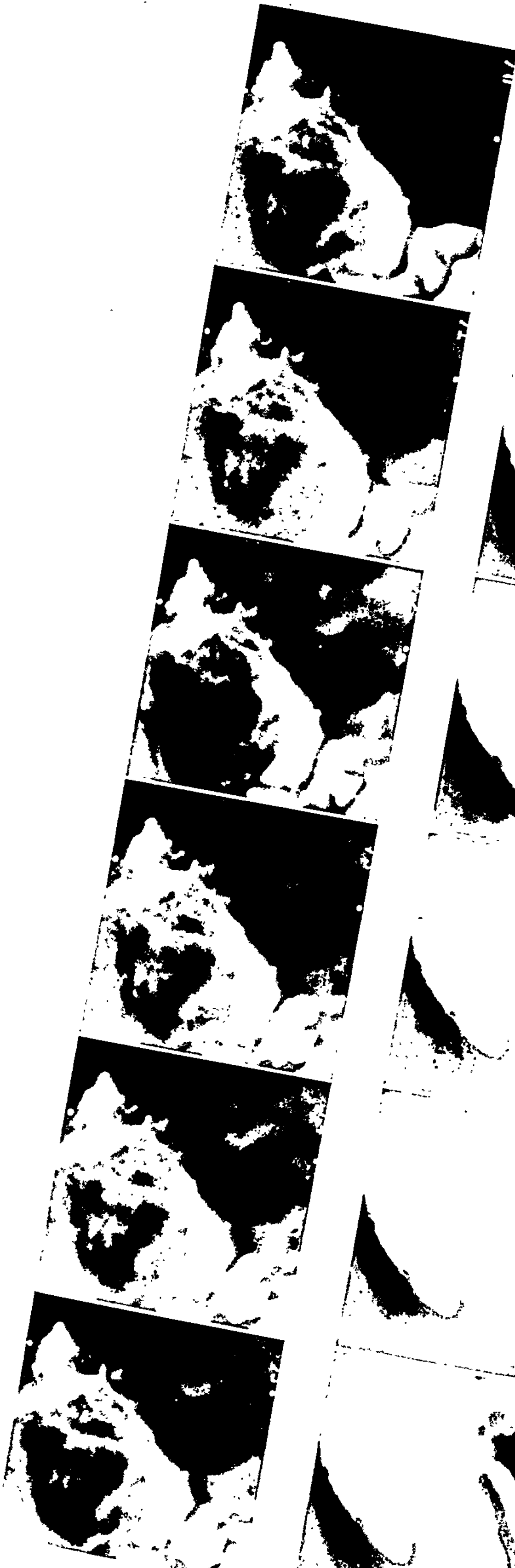

Fig. 1.

Fig. 2.
(See legends on opposite page)

Fig. 3.

is noted on the fluorescent screen. For the most part the terminal ileum appears to be quiescent, but many workers have probably noted occasional rush movements of the shadow from this part into the cecum. These movements are, however, usually too rapid and unexpected for accurate observation.

In view of the fact that the movements of the terminal ileum are generally so slow that they are almost unobservable on the fluorescent screen, the first case was recorded at a slow rate, *i.e.*, one radiograph every three seconds. Unfortunately, it so happened that in this instance, during the period of recording, an exceedingly active phase of movement was in progress, a rush movement, in which peristaltic waves propelled the ileal contents rapidly into the cecum (Fig. 4). Our rate of recording was, therefore, far too slow. Consequently, in our subsequent experiments we employed a rate of either two or three radiographs a second, but we have not again been fortunate enough to obtain a record of such a satisfactory emptying of the terminal ileum.

The movements of the ileum recorded on our films vary somewhat in character according to the site in which they occur. In general, they appear to be due to contractions of the muscular wall of the gut and not to the action of the muscularis mucosæ. It would be of interest to know whether the muscularis mucosæ is less well developed in this region, as compared with that of the duodenum and jejunum, in which, in all probability, we shall find that this structure is largely responsible for the shredding of the food and its onward passage.

Many of the movements recorded in our x-ray films may be seen in the ordinary cinematographic film of the exposed intestine of the cat and rabbit, made by Alvarez and Zimmermann (1). A careful study of this film has been of much value in deducing the type of muscular contraction that causes the changes in the shape of the contents as shown in our x-ray records.

Ileum.—Movements of the gut a little distance (perhaps from 8 to 12 inches) back from the ileocecal "valve" are well shown in some of the records (Fig. 1). These appear to be of a more or less peristaltic type, the contents being propelled through some inches of the gut by the passage of powerful contracting rings which move either forward or backward, for it seems that in this section peristaltic waves pass freely in either direction, driving the contents back and forth and inevitably churning and compressing them. The compression may well be an adjuvant to absorption. As in the terminal portion of the ileum, non-propulsive contractions may be superimposed. An example of this is seen in Figure 1, in which the non-propulsive contraction remains stationary while the propulsive contraction overtakes it.

Terminal Ileum.—The occurrence of changes in the outline of the terminal ileum is not constant and there may be long periods in which practically no alterations are observable in the shadows. The movements that have been recorded fall under two heads: (*a*) Those that are concerned with the churning of the contents and are non-propulsive, and (*b*) those that are chiefly propulsive in character.

(*a*) Ring contractions of peristaltic type

Fig. 1. Consecutive frames of a film taken at the rate of three frames a second. The cecum is as yet only partially filled with opaque food. Note (1) the progress of a peristaltic wave (in the lower right-hand corner) preceded by a preliminary contraction that is stationary and is overtaken by the true peristaltic wave; (2) a small contraction in the terminal ileum, in which, however, very little change is seen; (3) the rugæ, running more or less parallel through the ileocecal "valve."

Fig. 2. Alternate frames of a film taken at the rate of three frames a second, showing part of the progress of a non-propulsive ring contraction in the terminal ileum, which moved forward about one and one-half inches and then returned and faded out.

Fig. 3. Consecutive frames of a film taken at the rate of two frames a second. The cecum is as yet only partially filled with opaque food. A large non-propulsive contraction is seen about four inches from the ileocecal "valve," moving backward.

Fig. 4.

Fig. 5.

(See legends on opposite page)

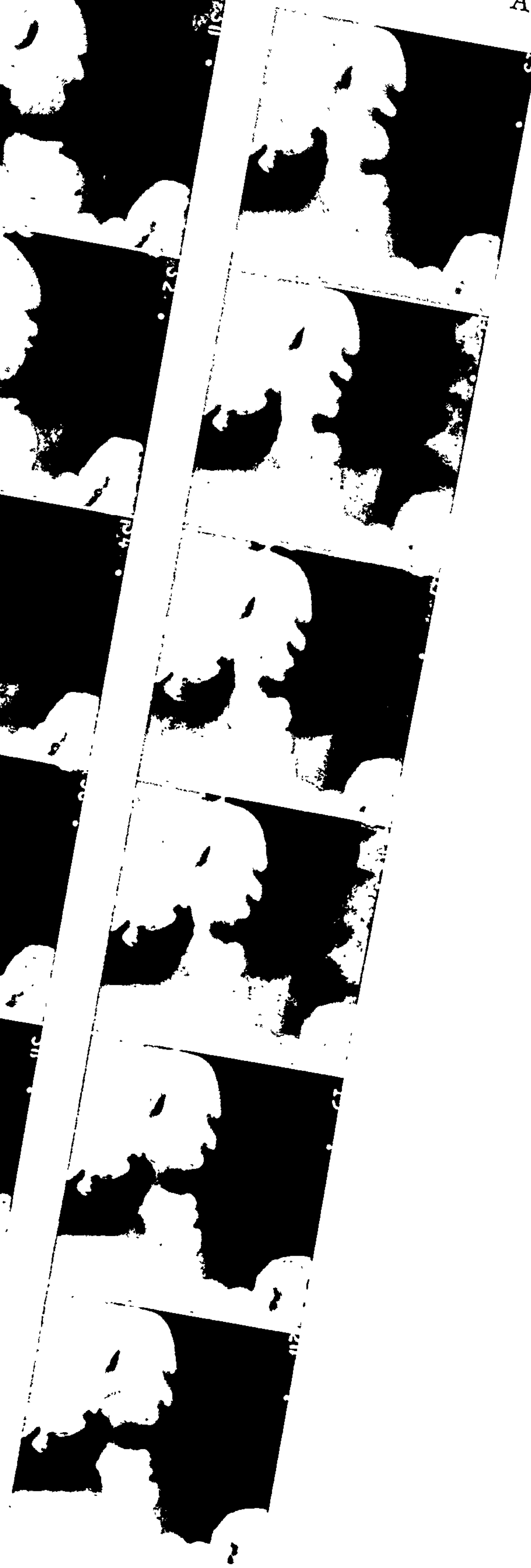

Fig. 6

cut into the shadow of the contents of the terminal ileum (Figs. 2 and 3). These contractions appear to be due to the action of the circular fibers. Usually they take a few seconds to develop and, meanwhile, slowly travel perhaps two inches, either toward or away from the ileocecal "valve." Although they look propulsive in character, they do not propel the food to any extent in either direction. They fade out or return on their course and leave the general picture unchanged.

Pendulum movements have been described, and these are also noted in our records. They seem to be due to the lengthening and shortening of sections of the gut, *i.e.*, to contractions and relaxations of the longitudinal fibers. For instance, the contents of the terminal ileum appear to sway slowly laterally. On analysis of two of the films, we find that this swaying is due to a lengthening of the last few inches of the ileum, which, therefore, swings away from or toward the relatively immobile cecum. It does not appear that such movements are of importance in the mechanics of digestion.

(*b*) At times deep peristaltic contractions cause rush movements that carry the ileal contents into the cecum. Most observers have seen these occur, but the changes are usually too rapid and unexpected for the eye to note exactly what happens. As already mentioned, in the first case we recorded, one of these rush movements was actually taking place, but as we had expected to find only slow movements, our exposures were made at a rate of one in three seconds, with the result that we obtained only intermittent pictures of a movement that should have been recorded as fast as possible (Fig. 4). In another case (Figs. 5 and 6), however, the food was passing into the cecum in large quantity, but comparatively slowly, so that our record, taken at a rate of three radiographs a second and extending over a period of 15 seconds, covered only part of a slow rush movement that might well have emptied the whole of the contents of the terminal ileum. Apparently, both rapid and slow rush movements may occur.

The contractions that produce these rush movements appear to be of the same character as those that do not propel but only churn the food. In some instances it seems as if these latter suddenly respond to some impulse and become propulsive. This may be due to a change in co-ordination, as is suggested in some of the records. When a non-propulsive contraction progresses in an outlined section, the gut in front of it dilates to accommodate the increased quantity (in the same way that an inflated rubber bag distends elsewhere when pressure is applied at one point), but the column as a whole is not displaced. When, however, the contraction is propulsive, the dilatation in front does not occur, with the result that the contents are propelled onward. In this action the longitudinal fibers may also play a part.

Ileocecal "Valve."—In some of our records the "valve" is wide open and filled (Figs. 5 and 6), and the contents of the ileum are continuous with those of the cecum. In others, as in Figure 1, rugæ are seen in the position of the "valve," giving the impression of two or more small parallel channels entering the cecum. This appearance suggests that at the time of the exposures the "valve" is open but empty, for the rugæ do not converge as they would

Fig. 4. Consecutive frames of a film taken at the rate of one frame in three seconds, showing a rapid rush movement in the terminal ileum, propelling the food into the cecum. The time interval between each two frames is too long for the progress of individual waves to be traced.

Fig. 5. Consecutive frames of a film taken at the rate of three frames a second. The appendix is partially filled, but does not show any movement. Two non-propulsive contractions are seen in the terminal ileum, near the ileocecal "valve," while a slowly progressive propulsive ring contraction forms and comes up from below. This last contraction, however, is not forcibly propulsive at this stage.

Fig. 6. Alternate frames from a later stage in the same film as that illustrated in Figure 5, taken at a rate of three frames a second. The propulsive ring contraction seen beginning to form in Figure 5 is progressing slowly, and is now apparently propelling the contents into the cecum. A little higher up in the terminal ileum a ring contraction forms, but does not progress.

to a closed valve, as, however, they do in Figure 2. In this case (Fig. 2), the "valve" is apparently contracted, for the rugæ converge from either side on a point which is presumably the site of the "valve."

Cecum.—In our records alterations are seen to take place in the haustra. These are usually very slow and sometimes no change occurs over long periods. Another movement, however, can be detected, *i.e.*, a very slow general contraction and relaxation of the cecum as a whole. This mechanism is not shown in the illustrations, as the period covered is not sufficiently long. Evidence that such changes are in progress can, however, be detected. In a record made some years ago, this systole and diastole is quite definite and would seem to indicate a mechanism in the nature of a pumping action, designed to propel the cecal contents into the colon. Possibly the sphincteric tract that Hirsch (7) believes to be present in the ascending colon may work in conjunction with this mechanism. The movements of the cecum will be studied in detail, and reported in a later paper, together with those of the colon.

SUMMARY

By means of direct x-ray cinematography the movements of the terminal ileum and the action of the ileocecal "valve" have been studied.

Activity in this region is stimulated by the taking of food (gastro-ileac reflex).

Two main types of contraction are noted: propulsive and non-propulsive or churning. The latter are for the most part slow, while the propulsive contractions that empty the terminal ileum are usually rapid "rush movements." Relatively slow contractions of the same type have also been recorded.

The ileocecal "valve" does not, in our records, appear to act in a valvular manner to prevent the passage of food. Although capable of contraction, it is seen in the records to be both wide open and empty, and also wide open and full, with no sign of narrowing. In no case did we see any indication of ileal contents being pressed up against it—as is seen at the pylorus—and we have the impression that it exerted little influence on the passage of food during the periods of our records. It is, however, likely that in the presence of inflammatory conditions it may exert a valvular action, as is indicated by the delay that is noted in this region in appendicular trouble.

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RADIOLOGY IN THE TEACHING OF ANATOMY[1]

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THE progress made by radiology in the examination of the human body has led to its increasing use in the diagnosis of disease, so that to-day every general practitioner must have some knowledge of the normal radiographic appearances of the body if he is to understand the meaning of the radiologist's report. The time has passed when it was sufficient only to read the report, as was so prevalent some years ago, without understanding, from an examination of the film, the reasoning on which the report was based. In the final qualifying examinations it has been the custom now for many years to examine candidates on the appearances shown by radiographs of pathological conditions. The clinical examiner has already recognized that radiological appearances are playing an ever-increasing part in the detection, study, and control of many diseases. It entitles him to expect from the candidate for examination a fair knowledge of radiological diagnosis, much in the way as a knowledge of morbid histology is expected from students in every qualifying examination. In many schools there has been no attempt to teach the student the appearances of the normal radiograph, so that he has attempted to learn the interpretation of radiographs of pathological conditions while he has had only a very superficial knowledge of the normal. It is plain that any attempt to teach students the meaning of radiographs showing abnormal conditions without first teaching them to interpret radiographs of the normal is like trying to teach morbid histology without having first a knowledge of normal histology. To remedy this, the Board of Examiners for Anatomical Study of the University of London, in April, 1938, decided that students presenting themselves for examination in anatomy must show some knowledge of the radiological appearance of the human body. As a result, the teaching of radiological anatomy, which had been in progress only at certain schools for a number of years, has now become general.

The radiological teaching in most schools is carried out by a radiologist appointed as demonstrator of normal radiology to the department of anatomy. It is necessary that a radiologist should carry out the teaching of radiology in close co-operation with the teachers of anatomy, because in most cases the demonstrator of anatomy has not the necessary technical knowledge. Radioscopy, in particular, should be carried out only by a radiologist, because of the injuries which may occur from overexposure to x-rays by inexperienced operators.

The teaching of normal radiology in the anatomy department, as well as making the subsequent teaching of radiographs of pathological conditions easier, also exerts a favorable influence on the student's approach to his anatomical studies. In particular, radiological anatomy lays stress on the distinctive features of the living subject as contrasted with the cadaver, and attempts to bridge the gap between the cadaver (which the student must dissect in order to understand the mechanism of the body) and the living body. By the teaching of radiological anatomy, the student quickly realizes that the human body can show wide variations and yet come within the recognized normal limits. Radiological anatomy, perhaps more than any other subject, draws attention to the wide variations which exist between normal individuals and the differences which may exist in the same subject under differ-

[1] This is one of a series of papers contributed by friends and former pupils of I. Seth Hirsch, M.D.

ent conditions and at different times. Emphasis must be laid on the importance of being able to co-ordinate radiological hospital and private practice he is going to be faced again and again with radiographs, and that the dissection he carries out on

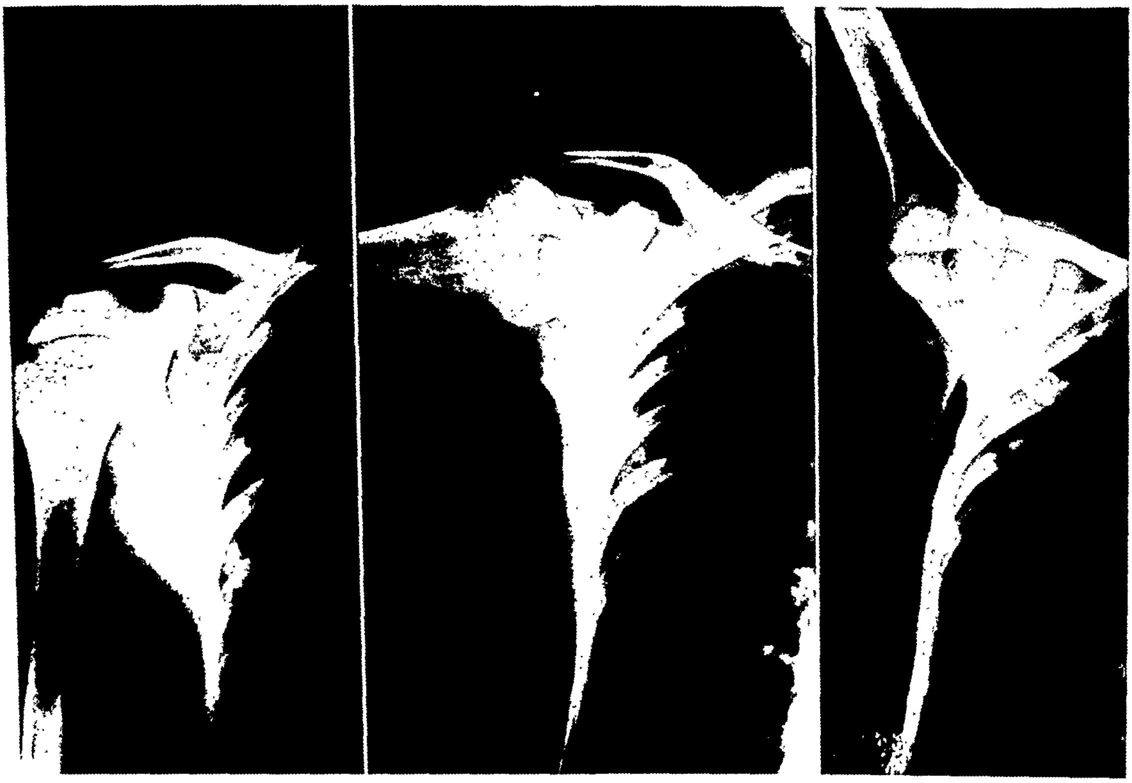


Fig. 1. Fig. 2 Fig. 3.

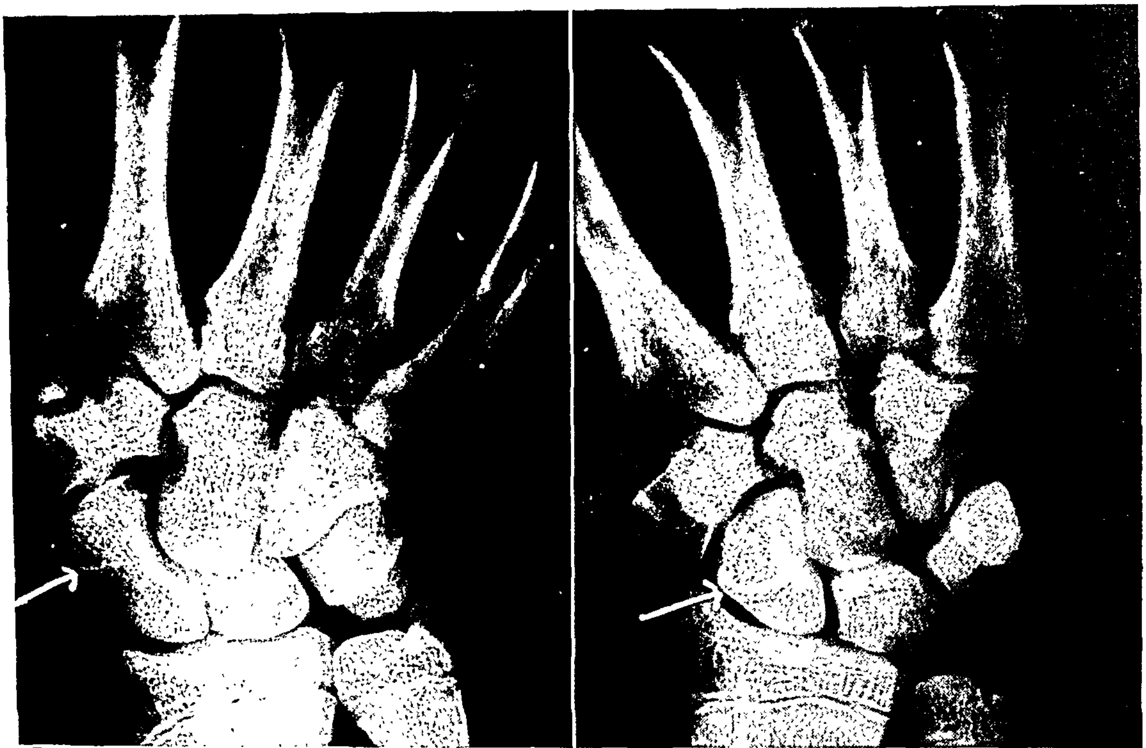
Figs. 1, 2, and 3. Movements of the shoulder girdle. Fig. 1. Position with the arm in adduction. Fig. 2. Position with the arm in 90-degree abduction. The movement takes place between the humerus and scapula. Fig. 3. Position with the arm at 180-degree abduction. Further movement has taken place by forward rotation of the scapula on the thorax.

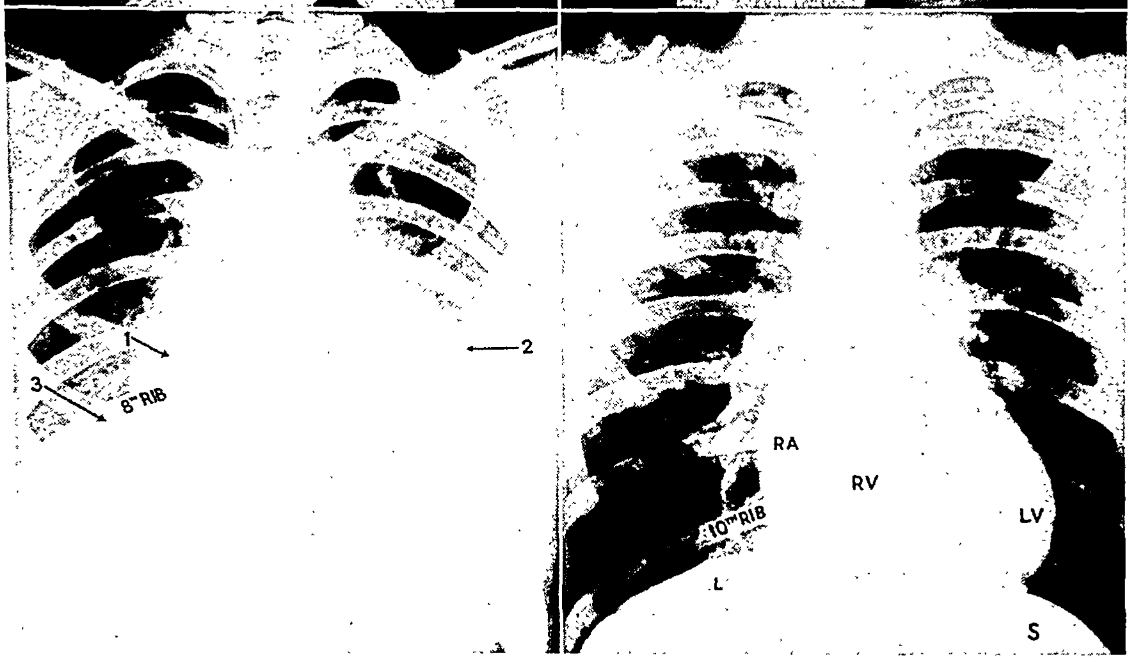
appearances with those features of the body which can be determined by external examination and those details which can be learned only by dissection.

The student rarely dissects any part of the body more than once, and it is a well-known fact that the average medical practitioner remembers very little of the detailed anatomical teaching which he acquires with so much labor. The effect of introducing the teaching of radiology into the study of anatomy has been rewarded by the increased interest which the student takes in the subject. By learning his radiological anatomy at the same time that he carries out his dissection, he is given a fuller understanding of many of the structures under dissection. He realizes that in the cadaver amplifies and explains what he can see in the radiograph.

The method by which radiological investigation helps anatomical teaching is seen in the study of the development of the epiphyses. A knowledge of the times of appearance and dates of fusion of the epiphyses with the diaphyses has always been expected of every student in examinations in anatomy. The importance of such knowledge is purely academic unless the student is able to apply this knowledge when he is qualified. By studying radiographs showing the stages in the development of the epiphyses and their fusion, the student learns not only the times of appearance and dates of fusion of the epiphyses, but also their radiographic appearances

and variations. This is necessary because, at a later stage in his career, he will have to differentiate between an epiphyseal line and a fracture, and he will more rapidly learn to detect separation of the epiphyses. In the elbow joint in particular, the ap-





Figs. 4 and 5 (*above*). Movements of the scaphoid as seen on the radiograph. Fig. 4. In ulnar deviation, the full length of the scaphoid is seen. Fig. 5. In radial deviation, the scaphoid has rotated so that the proximal part of the bone is rotated backward and the distal part forward.

Figs. 6 and 7 (*below*). Effect of respiration on the position of heart and diaphragm. These two radiographs show the changes in the level of the diaphragm in full expiration and full inspiration. The heart is displaced upward by the upward movement of the diaphragm and becomes more transverse in type.

pearance of the epiphyses in their various stages of development can more easily be learned by the student from suitable radiographs than from dissections. The extra ossicles in the hand and foot, which, because of their inconsistency and wide variations cannot be learned easily by dissection, are rapidly learned from radiographs. Though in the hand and foot the extra ossicles rarely give rise to pathological lesions, yet in the knee, if the position of the flabella in the head of gastrocnemius is not appreciated from anatomical dissection, it may be mistaken at a later date by the student for a loose body in the knee joint.

The examination of the movements of joints in anatomical teaching can best be seen by radioscopy and serial radiographs showing the different stages composing the movements. In this way the student acquires a better understanding of the parts played by the bones in limiting the joint movement and the relation of one bone to another during the movement. The importance of radiographs in the examination of the mechanism of joint movement is well illustrated in the shoulder. The movements of the arm from the position of rest at the side of the body to above the head by abduction is a compound movement. Figure 1 shows the familiar radiograph of the shoulder girdle with the arm at the subject's side. Figure 2 shows that with 90° abduction the movement takes place between humerus and scapula. With further abduction to 180°, the scapula is rotated and glides laterally and forward on the thorax. The lateral and rotatory movements are expected, but the forward movement can

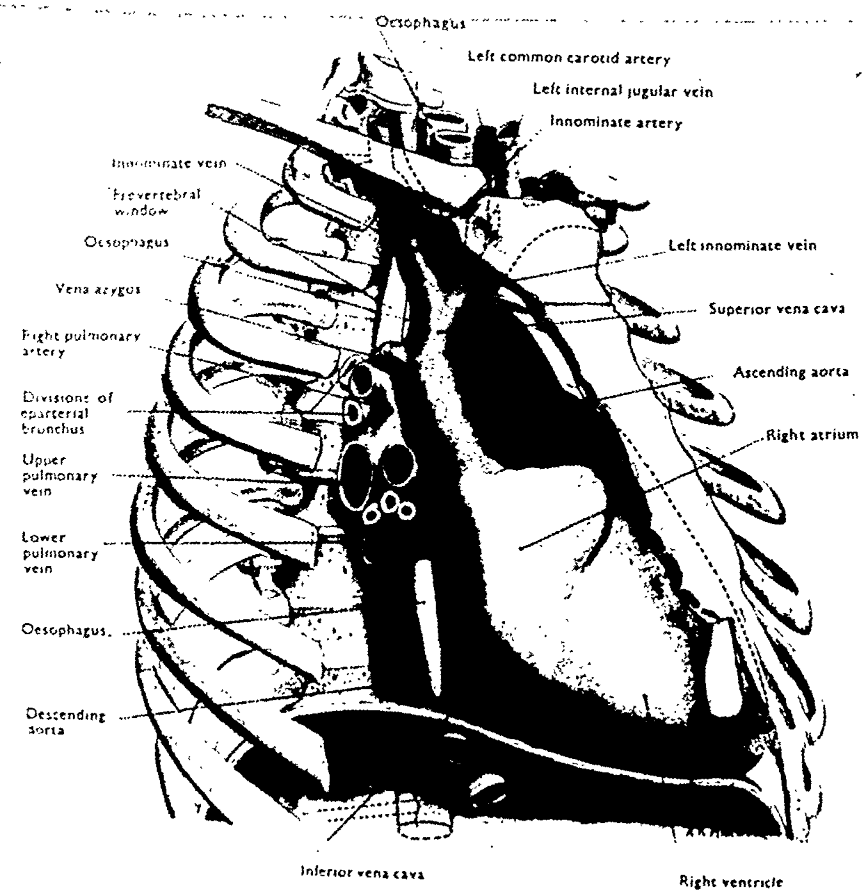


Fig. 8. Special dissection to show the anatomical relations of the prevertebral window and retrocardiac space as seen in the oblique position.

be appreciated only from radiographs and is not described in many anatomical textbooks. The glenoid fossa in Figure 3 is long axis of the radius. Figure 5 shows the hand in radial deviation. The scaphoid has now rotated through its transverse axis

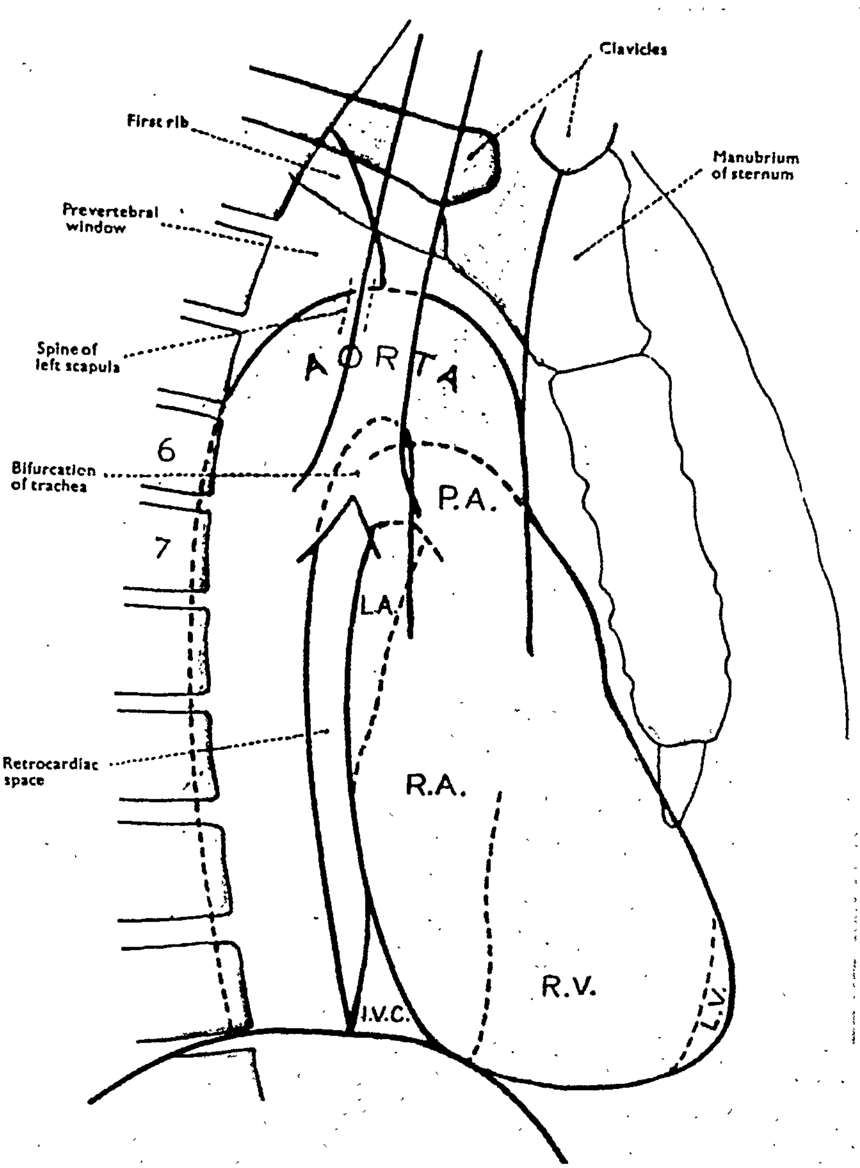


Fig. 9. Radiographic key to Figure 8.

directed upward and forward; the coracoid process is seen behind the clavicle, so that the coracoclavicular ligament has been rotated backward.

In a similar way, the complicated movements of the scaphoid bone in the hand can best be visualized by radiographs. Figure 4 shows the hand in ulnar deviation. The long axis of the scaphoid is seen to lie in the so that its proximal part is rotated dorsalward (backward) and the distal part ventrally (forward). In passing, it should be noted that fractures of the scaphoid are best seen with the hand in ulnar deviation, as in this position the full length of the bone may be seen in the postero-anterior radiograph.

A sound knowledge of the radiological

anatomy of the chest and abdomen is essential to the student carrying out anatomical dissection of these parts. It is in fixed level. The right dome of the diaphragm is stated to be on a level with the lower part of the fourth right interspace,

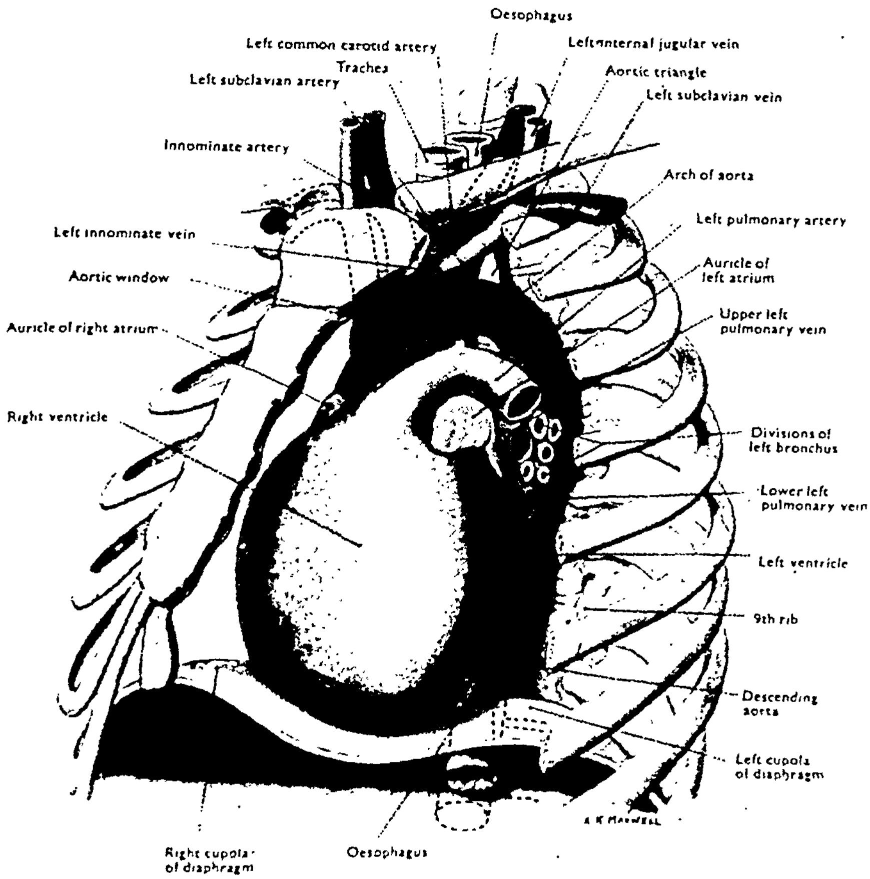


Fig. 10. Similar dissection to Figure 8, showing the relations of the aortic triangle and aortic window.

these regions that radiological study has brought about many revisions in the anatomist's ideas. Much of the anatomy of surface markings of these areas, which was compiled for the most part from the cadaver, has been re-written in the light of information obtainable by radiological methods. The teaching of the cadaver surface markings as applied to the organs of the chest and abdomen is, in the light of radiological teaching, no longer justified if the facts so learned are to be applied to the living subject. The surface marking of the diaphragm in the cadaver is given by Rawlings "Landmarks and Surface Markings of the Human Body" as a definite while the left dome is opposite the lower part of the fifth left rib and costal cartilage. The choice of such landmarks for the position of the diaphragm is not applicable to the living subject because of their inconsistency. The anterior parts of the ribs rise upward on inspiration as the diaphragm descends. A better landmark is the level of the diaphragm in relation to the vertebral column. Radiological examination shows that any table of levels for the diaphragm is modified by whether the patient is in the erect or prone position. Table I gives the level of the diaphragm as seen by a series of teleradiographic films taken in the erect position.

In many anatomical text-books the surface markings of the position of the heart, and even the heart valves, are given in (Compare Figs. 6[1] and 7.) It must be recognized that the usual surface markings of the heart as depicted on the anterior

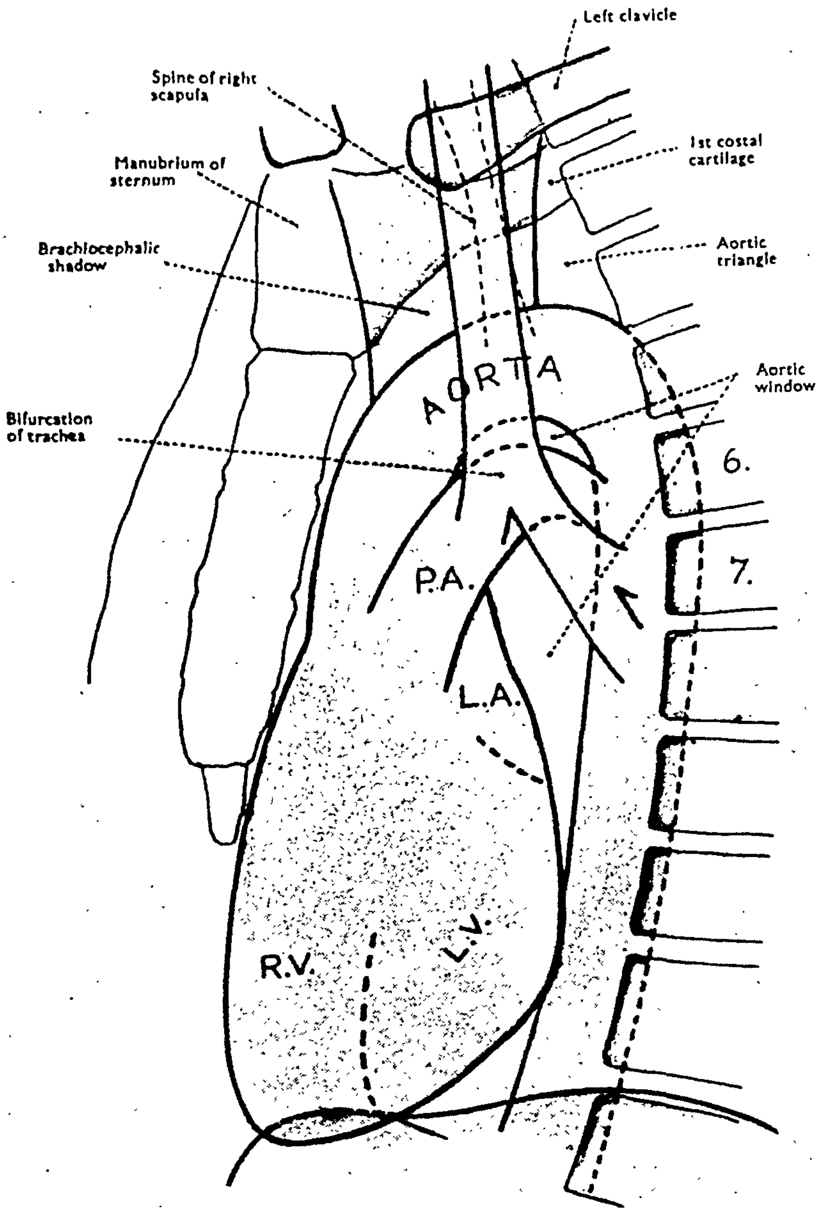


Fig. 11. Radiographic key to Figure 10.

great detail. If the chest is examined by radioscopy or by radiographs taken at full inspiration and full expiration, it is seen that at full expiration the heart shadow is placed at a higher level and more transversely on expiration than on inspiration.

chest wall are inaccurate. Even percussion of the heart's outline is not of much value when it is realized that the radiograph of the chest gives much more exact detail as to the position of the borders of the heart.

The importance of the right and left

oblique chest radiographs, in the examination of the heart for lesions, makes it necessary that the special dissection of

TABLE I.—SHOWING UPPER LIMIT OF DIAPHRAGM[2]

Diaphragm	Right Dome	Left Dome
Full inspiration	Body of eleventh dorsal vertebra	Body of twelfth dorsal vertebra
Full expiration	Body of ninth dorsal vertebra	Body of tenth dorsal vertebra

these parts should be considered. Figure 8 shows such a dissection, with the radiographic key (Fig. 9). It is very important that the student should know the relations forming the prevertebral window and retrocardiac space. Figure 10 shows the relations of the aortic triangle and aortic window. Figure 11 gives the radiographic key. This is in addition to the usual anatomical teaching and is of great cardiographic importance from a clinical standpoint.

The position of the abdominal organs shows such wide variations in the living, in the erect and prone positions, that a knowledge of their surface markings as gained from the cadaver is misleading since they are described as being at fixed points. The conventional anatomical surface markings of the position of the stomach as shown in anatomy text-books should be modified in the light of radiological findings. Such surface markings are of no help from a surgical standpoint and from a clinical examination point of view are practically valueless. The student studying the gastro-intestinal canal by means of radioscopy and radiographs quickly realizes that the position of these organs in the abdominal cavity depends on the degree of the distention and tone of the organ, and that their position is also influenced by the tone of surrounding tissues. Respiratory movements also vary the position of the abdominal organs. In the case of the stomach, the up-and-down movement may be as much as three inches. Gravity also plays a part in the position of the organs, which descend when the subject moves from the prone to the erect position. In the case of the ureter, its surface marking is given for the cadaver as a line drawn vertically from the level of the spinous process of the second lumbar vertebra to the posterior superior iliac spine. By excretion radiography, it can be shown that the ureter rarely occupies this position. It is sometimes seen to take a curved course and become bowed toward the center line as the kidneys move with respiration.

From the foregoing it is apparent that the introduction of radiology into anatomical teaching must modify and in some cases correct many ideas of anatomical teaching which are applicable only to the cadaver. The student's interest in dissecting the cadaver is to learn facts which he may be able to apply at a later date to patients. The use of radiology in teaching anatomy helps to bridge the gap between the living and the dead.

[2] Appleton, A. A., Hamilton, W. J., and Tchaperoff, I. C. C.: Surface and Radiological Anatomy. Cambridge, 1938.

MEGADUODENUM AND DUODENAL OBSTRUCTION[1]

CRITERIA FOR DIAGNOSIS

By MILLS STURTEVANT, M.D., *New York City*

MEGADUODENUM is said to have been described as early as the middle of the eighteenth century (1). It has taken a place in clinical medicine since roentgen study of the gastro-intestinal tract became a part of diagnostic procedure. The possibility of intermittent obstruction at the duodenojejunal angle has been recognized and a causal connection with megaduodenum has seemed demonstrable to some. It is the purpose of this paper to present a case of megaduodenum and to discuss the criteria for diagnosis of duodenal obstruction.

Case 1. A young girl, 18 years old, born in England, had lived with her parents in different countries where her father's business had taken them. He was a mining engineer and his work had not only required their living in different countries but also for periods, in out-of-the-way places where their choice of food was limited and living conditions otherwise primitive. The patient had a lateral curvature of the spine and had been subject to digestive upsets when she would vomit, complain of abdominal distress, and be incapacitated for short periods. After these attacks she would make rapid recovery. The attacks had been regarded rather indefinitely as "regular children's vomiting" and had become less frequent as time went on. Shortly before being seen, the patient had been operated on for her spinal deformity and an extensive plaster cast was applied, encasing her entire body. The day after the operation she began to vomit and continued to do so whenever she ate. In ten days she had lost as many pounds in weight.

The films shown in Figures 1 and 2 were made. A hole was cut in the cast and the ascending colon was lifted, with the hand inserted in the hole thus made. Postural treatment was suggested, with the patient lying on her stomach and walking on her hands and knees. A liquid diet was given at first and then soft solids. A symptomatic recovery resulted almost immediately and this was continuous, after the cast could be removed.

Both megaduodenum and duodenal obstruction have been described at length and various views of a possible relationship have been expressed. The papers of Bockus (2) and Kellogg (3), and the monograph of Duval (4) give the history of the development of knowledge concerning the two conditions and give extensive bibliographies. Duodenal obstruction has been described with pressure of peritoneal bands (5, 6) congenital and inflammatory, the latter secondary to peptic ulcer (7, 8), biliary and pancreatic infections, malignancy of the stomach or of neighboring organs, or the pressure of the newgrowth or other pressure from without, or obstructive pathology of the duodenum itself.

It has seemed to various duodenologists (10, 11, 12, 13, 14) that compression of the duodenum by the mesenteric artery in the root of the mesentery may furnish or help to furnish partial obstruction and that the very angularity of the gut is also a factor. Since an asthenic habitus would increase the angularity of the duodenojejunal loop and decrease in bodily fat would increase the tug of the mesentery and make the mesenteric artery more prominent and rope like, one would expect to find the condition more often in the asthenic and in fatigue and debilitated states. This is said to be the case. A weight of evidence in favor of such a condition, responsible for a symptom-complex accompanied by par-

[1] This is one of a series of papers contributed by friends and former pupils of I. Seth Hirsch, M.D.

Fig. 1.

Fig. 2.

Fig. 1. Megaduodenum.
Fig. 2. Megaduodenum. Six-hour film showing residue in the stomach, the cap, and at the bend of the duodenum.

oxysmal vomiting, sometimes pain, and sometimes severe headache (15), is considerable. The monograph of Duval (4) discusses the anatomy and pathology at length.

It would seem that, with dilatation of the duodenum and delay, one had roentgen evidence of obstruction, yet this has been denied by some. Downes (16), who observed a case in a child, regarded the enlarged duodenum as similar to the enlarged colon in megacolon. Duval (17) has held a similar view. Certain students (18, 19, 20, 21) of upper abdominal symptoms have thought that actual mechanical obstruction was not necessary and that the condition might be due partly, or wholly at times, or even always (21), to functional obstruction, part of an autonomic phenomenon, with central factors, variously described by different authors as "emotional states," "nervous impressions," or "hysterical conditions."

Roentgen criteria for diagnosis have been suggested. These have consisted of the following: duodenal antiperistalsis, duodenal stasis, violent duodenal peristalsis, the "writhing duodenum," and "full-filling" of the duodenal cap. To these there might be given some study.

Jordan (22), in 1923, described the distended duodenum struggling to expel its contents, "writhing energetically in futile effort," and Wheelon (23) has published a study supporting this view. That this means obstruction at the duodenojejunal angle has been disputed by Case (24) and others who have found the writhing duodenum in supine position, with rapid emptying of the stomach, and as a transient phenomenon without demonstrable cause. Bloom and Arens (25), in 1927, published a study of 200 cases showing duodenal stasis, 50 of whom were operated on. In all but 10 of the patients in this series, an irritative focus was found near. Gall-bladder disease, duodenal ulcer, and appendicitis were the most frequently associated diseases. These writers state that chronic duodenal ileus due to mechanical obstruction is rare. They regard antiperistalsis, writhing duodenum, and duodenal delay as roentgen signs of other pathology. Usually the contrast meal can be seen to enter the duodenum and when it reaches the second or descending portion it becomes split up into small amounts. This is caused by the valvulæ conniventes and is sometimes called feathering. If the duodenum is distended or dilated, it becomes filled by the contrast material and the feathering is not seen but the shadow

Fig. 3. Fig. 4.

Fig. 3. This duodenum shows "full-filling." It was also said to show writhing, antiperistalsis, and regurgitation.

Fig. 4. Showing duodenal filling with very little history of upper abdominal disturbance.

is solid and homogeneous. This "full-filling," at the bend of the duodenum between the descending and ascending loops, sometimes called the knee, has been regarded (26) as pathognomonic of duodenal compression.

When diagnostic criteria are vague and not always dependable, the condition to which they are supposed to point may become a diagnostic refuge for any atypical or ill-defined symptoms for which we are at a loss for an explanation. Films of two additional cases are given here, selected from a number of cases in which the diagnosis of obstruction at the angle of Treitz was made but in which the diagnosis was at least incomplete and detrimental to the patient.

Case 2. This patient, treated for a productive osteo-arthritis of her hands, was given cinchophen over a long period. She developed dyspeptic symptoms and although she was 57 years old and had never had gastro-intestinal trouble, the diagnosis of duodenal obstruction was made and postural exercises and a fluid diet advised (Fig. 3). She shortly became jaundiced and her liver necrosis brought out the fact of her medication. The cinchophen was stopped; she recovered and her dyspepsia was gone.

Case 3. A man, 34 years old, had always been well until six months before when he became very constipated. His movements were bloody. He was told he had hemorrhoids and was given a salve. After two or three months, his constipation gave way to diarrhea with mucus and blood. There was considerable urgency but movements were, at worst, only six or eight a day. His film showed some dilatation of his duodenum which brought out the history of vomiting at long intervals, over the last 15 years. He thought it had usually been when he had eaten unwisely, but his diagnosis became duodenal obstruction. After some time, money, and effort were lost, a proctological examination showed the presence of an ulcerative colitis. In two years he has had no vomiting and no other upper abdominal dyspepsia, showing that it is possible to show not

only a "full-filling" but also some duodenal dilatation with few or no symptoms (Fig. 4).

It is not the purpose of this paper to deny the existence of arteriomesenteric compression of the duodenum. The author believes that duodenal obstruction is a definite entity. It is, however, suggested that such a disease is seen but rarely in a large charity hospital in New York City, and that the roentgen criteria which have been suggested for diagnosis are not always conclusive when present.

SUMMARY

A case of megaduodenum is presented. The roentgen signs supposedly pathognomonic of duodenal compression are discussed. It is suggested that these signs are not always associated with symptoms and that care should be used in accepting them.

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REDUCING THE TOXIC PERIOD IN HYPERTHYROIDISM[1]

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IN the discussion of any medical problem, clearness and definiteness in presenting the thought we wish to impress, as well as brevity and conciseness, are appreciated by all readers of medical literature, but seem to be overlooked by many writers. The kernels in many nuts go undetected because of the perambulations of those seeking to call them to our attention.

In the treatment of hyperthyroidism by x-rays, it has been our conviction for some years that the dosage given, even by those of wide experience, is insufficient for the best interests of the patient. This is the thought we wish to impress at this time. We will be brief and will attempt to be concise and clear.

For the purposes at hand, it is hardly necessary to call attention to the fact that the basic etiological factors in hyperthyroidism are not definitely known. Whether the thyroid gland solely is at fault, or whether its function is disturbed indirectly through extraneous influences, is likewise uncertain. These uncertainties should have great weight in determining the therapeusis in all cases of hyperthyroidism.

As the mysteries and intricacies of the ductless gland system unfold, it is well to bear in mind the possibility that there may be other functions of the thyroid gland than those now recognized, which in turn, may be factors in the proper coordination not only of the ductless gland system, but of physiological processes in general. Yet we do know that the surgical removal of the thyroid, or proper radiation of the gland alone, will restore the patient to normalcy. Hence, until further development, therapy addressed to the thyroid appears to be the proper procedure.

With these logical thoughts and facts before us, we are again impressed with the principle that no organ of the body should be removed because of dysfunction or excess function, when it is possible to correct its functioning processes. When there is present an excess function of an organ, the application of an agent which depresses this function is logical and scientific. The application of an agent which destroys an organ because of excess function, is illogical and unscientific. Thus is contrasted the background of surgical and roentgen therapy in hyperthyroidism. We shall not enter a discussion of x-ray *versus* surgical treatment of hyperthyroidism, neither a statistical presentation of the results of each: they are easily accessible and well known to those interested.

The depressant action of roentgen rays in all conditions characterized by hyperfunction or excess cell activity is recognized, and is borne out by experimental studies and clinical experience; likewise, the resistance of cells in normal activity to radiation is well known. The one and only argument deserving consideration which has been advanced against roentgen therapy for hyperthyroidism is the *time* usually consumed in bringing the patient to a non-toxic state.

Small dosage at long intervals seems to be the practice generally followed. Even those securing 90 per cent and upward of ultimate cures are consuming from six to nine or more months in the treatment of their cases. We all know what prolonged toxicity means in hyperthyroidism. The criticism advanced by our surgical confrères that we allow our patients to remain toxic too long, is, in many instances, a just criticism.

The object of the surgeon has been to abruptly and with one stroke remove the source of toxicity, the thyroid gland. It has not been argued or shown that the

[1] This is one of a series of papers contributed by the friends and former pupils of I. Seth Hirsch, M.D.

abruptness of itself, in removing the toxicity, was deleterious to the patient. Why not, then, as abruptly and with as few strokes as possible, suppress this toxicity by radiation?

CHART I

1936	Pul.	Trem.	Exo.	Enl.	Wt.	Met.	Rad.	Med.
6/13	130	3+	0	2+	98	+44	1200r	Quin.
6/20	110	2+	0	2+	96	+37	800	"
6/27	110	2+	0	1+	97	+30	600	"
7/4	100	1+	0	1+	95	+30	800	"
7/18	90	1+	0	1	96	+28	600	"
8/1	100	1+	0	1	95	+30	600	"
8/15	100	1+	0	1	98	+32	600	"
8/31	80	0	0	0	103	+1	0	0
10/8	80	0	0	0	113	+1	0	0

200 kv., 0.5 mm. Cu, 2 ant. lat., 1 pos. port.

Following the use of comparatively large doses of x-rays in extremely toxic cases of hyperthyroidism, we have never seen any ill effects. On the contrary, by the application of rather intensive dosage we have seen only good results, the most toxic cases becoming non-toxic in from four to ten weeks, rather than in from six to nine months. By rather intensive dosage, we do not mean intensive as far as skin tolerance is concerned, but intensive compared to the usual dosage advised.

If the metabolic rate is running high, plus 50 or more, the application of 750 r weekly, dividing the dose over three areas, right and left anterior lateral and posterior, with a kilovoltage of about 130, 3 mm. Al filter, is the minimum dosage indicated. This may be repeated from six to eight times at seven-day intervals, with no ill effect on the skin. Checking the metabolic rate each week, these doses should be spaced at longer intervals or decreased as the metabolic rate falls. The metabolic rate should be reduced to zero before discontinuing treatment, else a rebound will inevitably follow.

The fear of myxedema following x-radiation is hardly to be considered when radiation is applied intelligently. Prolonged excess function of the thyroid cells is, in many cases, followed by cell exhaustion, regardless of what type of therapy has been used. Intense radiation given over the thyroid area in cases in which the thyroid is normal, has not shown any bad effects on the gland.

CHART II

1932	Pul.	Trem.	Exo.	Enl.	Wt.	Met.	Rad.	Med.
5/21	140	4+	2+	2+	85	+60	750r	Quin.
5/28	130	4+	2+	2+	85	+62	750	"
6/6	130	3+	2+	2+	87	+50	750	"
6/13	110	2+	2+	1+	87	+42	750	"
6/20	100	1	2	1+	92	+26	300	"
7/4	100	1	2	1+	96	+18	300	0
7/18	80	0	1+	1+	100	+10	0	0
8/8	80	0	1+	1	104	+5	0	0

130 kv., 2 mm. Al, 2 ant lat., 1 pos. port.

Under circumstances in which it is difficult because of distance or other causes to give weekly applications, still more intensive dosage may be applied at fourteen-day intervals (200 kv., 0.75 mm. Cu filtration, with 1,200 r distributed over three areas). This technic may likewise be repeated with safety, but will not require as many applications, because the metabolic rate falls rapidly.

In the treatment of all cases, foci of infection should be removed, iodine withheld, and quinine used liberally, with, of course, restrained activity as indicated.

The two charts here presented indicate the conditions existing in two typical cases of hyperthyroidism, with the treatment usually given, and the results usually obtained.

Case 1 (Chart I) was one of our most resistant cases, yet from June 13 to August 31, a period of ten weeks, it was noted she became toxic-free.

Case 2 (Chart II) illustrates a low voltage technic with one-week intervals in treatment, the patient becoming non-toxic in approximately seven weeks.

If radiation were applied regularly in cases of hyperthyroidism, in dosage needed, the one logical argument used against it would fall.

ROENTGEN-RAY TREATMENT OF SKIN CANCER[1]

By CHARLES W. PERKINS, M.D., *Norwalk, Connecticut*

CANCER of the skin usually begins in abnormal tissue, such as a wart fissure, old scar, thickened skin, and from prolonged irritation due to dirt, dust, or wind. It is frequently found in elderly patients whose skin is thickened and in those individuals who have led lives exposed to the weather, as well as in persons living in rural districts who seldom use warm water and soap for cleansing purposes. If these pre-cancerous lesions are cured, no carcinoma will develop. Cancer of the skin is very often ignored as it causes very little discomfort. It is an appalling fact that four thousand deaths occur in the United States each year from skin cancer. I have noted with surprise that in certain rural communities skin cancer is permitted

[1] This is one of a series of papers contributed by friends and former pupils of I. Seth Hirsch, M.D.

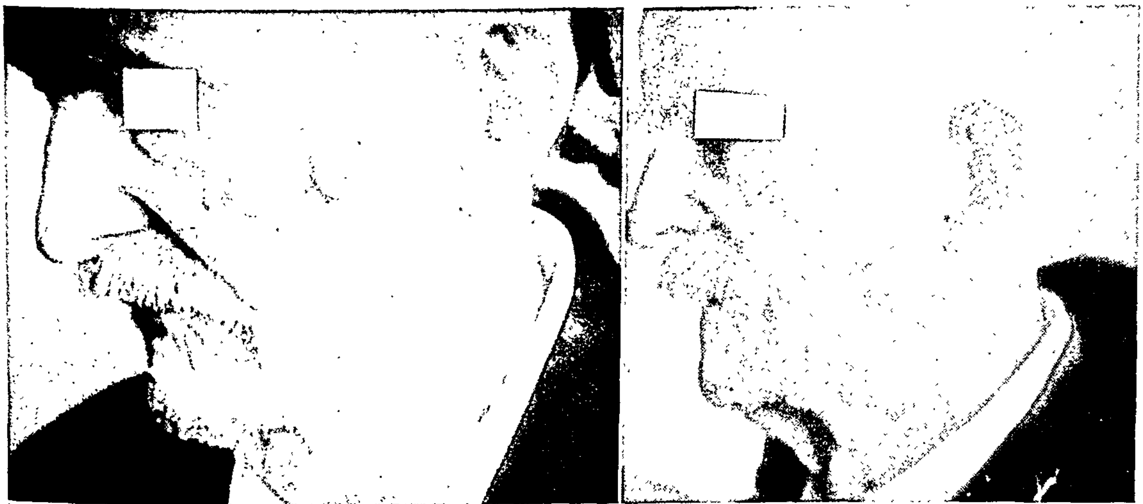

Fig. 1 (*above*). Mr. K., aged 79, Aug. 7, 1934, papilloma. Question of epithelioma, 2 cm. wide and 6 mm. high. Duration, six months. Treatment, 3,400 r units, unfiltered, within nine days. Healed perfectly by Sept. 21, 1934.

Fig. 2 (*below*). Mr. T., aged 85, April 4, 1938, epidermoid carcinoma, 5 cm. long and 3.5 cm. wide, ulcerated, one-year duration. Bad teeth. Heavy smoker; whole lip swollen, edematous. Treatment, 10,000 r units, unfiltered, within a week. Healed, June 6, 1938, with good cosmetic result.

to reach the advanced stage before medical aid is sought. This is partly due to ignorance on the part of the patient who *does not realize the gravity of the condition*. This type of patient will treat a skin lesion with ointments and salves. He has no way of knowing that the irritating effect of such treatment aggravates his lesion. A few years ago I saw a patient with one-half of his face eaten away with carcinoma before he even consulted a physician. The case was so far advanced that it was impossible to do anything for him. If such cases are treated early, from 95 to 98 per cent can be cured permanently.

Chronic irritation is recognized as probably *the most important factor in the stimulation* of abnormal cell growth. As the proliferation continues, the vitality of the part decreases and in the older center cells necroses and ulceration are produced.

Ninety per cent of skin cancers develop on the face, neck, and hands. Areas not protected by clothing are especially vulnerable. About two-thirds are basal-cell type and one-third are squamous-cell carcinoma.

Fig. 3 (*above*). Mr. C., aged 82, July 22, 1935, basal-cell carcinoma on ear, 1.5 cm. wide. Nine months' duration. Treatment, 6,000 r units, unfiltered, within seven days. Healed perfectly by Oct. 1, 1935. No return to date.

Fig. 4 (*below*). Harry V., aged 65, Feb. 9, 1935, basal-cell carcinoma, circumscribed ulcer, raised surface, bleeds easily, two and one-half years' duration. Treated with several kinds of applications without result. Treatment, 6,000 r units, unfiltered, given within one week. Healed by April 15, 1935. No return to date.

Basal-cell cancer usually occurs in persons beyond middle age. It may begin as a papillomatous lesion, the so-called rodent ulcer which is slow in destruction of the surrounding tissues. The characteristic lesion is ulcerative, with a raised pearly border, and is common on the face, especially above the lip line. However, it may occur on the neck, arms, back, chest, legs, buttocks, and perineum. Basal-cell can-

Fig. 5 (*above*). C. P., aged 69, Dec. 21, 1934, squamous carcinoma 3 cm. wide, raised surface. Four months' duration. Treatment, 6,000 r units, unfiltered, within a week. Healed with perfect cosmetic result by Feb. 21, 1935. No return or metastases to date.

Fig. 6 (*below*). Mrs. N., aged 86, July 16, 1936, basal-cell epithelioma (began as pimple seven months before), 1.5 cm. wide. Treatment, 6,000 r units, unfiltered, within 12 days. Healed with perfect cosmetic result, Aug. 27, 1936. No return to date.

cers seldom metastasize, but if they are of long standing, may develop to such an extent as to become incurable.

Squamous-cell carcinoma is differentiated from the basal-cell carcinoma in that it forms prickle cells and epithelial cells with protoplasmic processes between them. There is a mixed cell type which has some basal and some squamous cells, which occurs in a small percentage of the cases.

One method of grading malignancy of the skin cancer is based on the number of malignant cells or the amount of tumor cells as they approach the normal. As a rule, the more embryonic or lower cells present in the tumor or specimen, the quicker the response to radiation. The higher grade the cells, the more radioresistant. The clinical symptoms, age of the tumor, and the amount of infiltration should govern the amount of treatment and decide the probable response to radiation.

All pre-cancerous lesions, such as moles, warts, crusts, and fissures, should be eradicated. Such lesions can be removed by electrocoagulation followed by irradiation. They can, however, be removed by x-ray therapy alone, if sufficient dosage is given.

Almost since the discovery of roentgen rays skin cancer has been treated successfully by this method. Much controversy has arisen at times between the value of the x-ray and radium for treatment of these tumors; however, there seems to me to be no real reason for this controversy, for skin cancer can be treated successfully by either x-rays or radium. The biological action of the x-ray is for all practical purposes the same as that of radium. Treatment can be given with x-ray in less time and with less expense involved, and a beautiful cosmetic effect is the result. Compared with the scalpel, there is much less danger of spreading the malignancy into the blood stream and thereby causing metastasis elsewhere in the body. X-ray is a painless method of treatment. No anesthesia is required. The patient can receive treatment in the office, thus eliminating the item of hospital expense.

Fig. 7.

Fig. 8.

Fig. 7. Miss Y., aged 65, operated on on May 24, 1932, adenocarcinoma of right breast with axillary involvement. Recurrence. Operated on in May, 1933, and April 26, 1934. From July 3, 1934, to June, 1935, four series of x-ray treatments were given—135 kv., 3 mm. aluminum filter. Marked reaction obtained after each series. Patient well in November, 1938.

Fig. 8. Miss M., aged 69, cancer of right breast, no axillary involvement. Operated on in April, 1933, ribs removed. May, 1935, recurrence, three nodes in operative scar. Nodes, 1 × 2 × 3 cm., raised from surface, dark blue in appearance. Treated with unfiltered x-ray, 3,500 r units. Whole area breast treated with filtered x-ray, 135 kv., June 4, 1935, healed. X-ray of chest taken. No metastases. Patient well in November, 1938.

Intensive doses are given to the growth, depending on the size and depth. Between 2,500 and 10,000 r units, or 5 to 20 skin units are used. Treatments are given within a week or ten days. Subsequently, the tumor usually sloughs out within from three to four weeks and is healed with good cosmetic result in from six to eight weeks' time.

I have never used above 110 kv. unfiltered. There seems to be no real reason for higher voltages or deeper penetration as the growths are on the surface, usually not any deeper than from 1 to 1.5 cm.

In regard to skin cancer, it cannot be emphasized too strongly that practically all such lesions can be cured if thoroughly treated in the early stages by intensive doses of x-ray under the present skillful methods available. If skin cancer is treated incompletely with insufficient dosage, picked at, so to speak, or irritated by unskillful methods until it involves the deeper structures, then failure will occur and the greatest skill of the surgeon in combination with x-ray and radium therapy will give the patient only a fighting chance.

Unskillful methods resulting from insufficient training and experience will mean failure and the x-ray as a therapeutic method for treating skin cancer will be held in disrepute.

AN X-RAY STUDY OF THE LUNGS OF WORKMEN IN THE ASBESTOS INDUSTRY, COVERING A PERIOD OF TEN YEARS[1,2]

By ARIAL W. GEORGE, M.D., and RALPH D. LEONARD, M.D., Boston, Massachusetts

DUST inhalation is a subject in which we have been particularly interested for the past ten years. Our approach to this problem has been through the medium of the x-ray. During the past five years, the dust hazard in many industries has become a serious economic factor, for the individual workman as well as for the corporation and insurance company. In some instances the amount of alleged disability among the workmen, from dust, had reached such proportions that insurance companies became insolvent, and the industrial plants were forced to close for lack of compensation insurance protection.

During this period, we have had the opportunity of studying the chests of over three thousand workmen exposed to a dust hazard in their regular occupation. This group included various types of dust hazards—mining and manufacturing—and from various parts of this country, east of the Rockies. From this group it has been our privilege to observe with the x-ray the changes in the chest which may result from more or less continuous exposure to various types of dust, such as silica, talc, marble, coal, asbestos, heavy metals, such as iron and brass, and various organic dusts, such as wood fiber.

In this rather cursory paper, it is our purpose to record our observations and conclusions based on an x-ray study of one type of dust hazard, namely, asbestos dust. The disease condition resulting from the inhalation of asbestos dust is that form of pneumoconiosis known as asbestosis. We shall comment on this disease, as an economic problem, as it concerns the insurance companies and the industrial accident boards, and also as a disease condition in the individual, its pathology and prognosis as observed by us through the x-ray.

In 1928, we began the intensive study of those exposed to the asbestos hazard in one of the large industrial plants in Massachusetts, where brake lining was manufactured. The hazard created was principally asbestos, with less than 30 per cent silica. Dry weaving was first used and then changed to wet weaving. This change was brought about by the fact that in 1928 and 1929 there were numerous cases which showed symptoms, referable to the lungs, characterized by increased difficulty in breathing on exertion, cough, sleeplessness, and loss of weight. Of all the cases we examined in 1928 and 1929, our records show that in 12 cases x-ray examination revealed changes in the lungs, upon which we based our diagnosis of asbestosis. These 12 were at once put on compensation or given a lump-sum settlement and have been under observation for seven years, throwing considerable light on the natural progress of the disease. From about 1928 to 1933, we routinely examined those cases suspected clinically of asbestosis. By 1933 the insurance premiums had pyramided to 15 per cent of the payroll, and the carriers were rather indifferent to the taking on of this risk. Finally, one of the large companies decided that before they took over this risk, they would have examined, clinically and by x-ray, all of the employees of the plant, totalling approximately eight hundred. The majority of these workmen were examined by us immediately at the plant. There was a very small number of the total employees whose conditions we diagnosed as asbestosis. Out of this number that we either suspected or diagnosed asbestosis, there were three cases that were definitely advanced. These three cases were of interest because they did not show

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[1] Read (in part) by invitation at the Twenty-fourth Annual Meeting of the Radiological Society of North America, at Pittsburgh, Nov. 28–Dec. 2, 1938.

[2] This is one of a series of papers contributed by friends and former pupils of I. Seth Hirsch, M.D.

many of the usual clinical signs; and would not, on account of the high wages they were earning, change their occupations. These three men continued to work until the plant was closed, in 1936. One of the three became a litigant later. The other two disappeared into other industries and are not recorded as claiming disability to date.

A survey of this type naturally revealed many interesting lung conditions aside from asbestosis, such as aneurysm, early healed, active and chronic tuberculosis, heart abnormalities, and many cases of residual changes from previous lung diseases.

The plant was eventually sold to a competitive company and was immediately closed. Within a short time after the closing of the plant, 90 workmen brought in claims for disability due to asbestosis. These 90 cases were examined by us by x-ray and we made a positive diagnosis of asbestosis on 12, with three additional cases questionable. About 13 per cent of the positive x-ray diagnoses, in this group of 90, claimed symptoms of asbestosis. The insurance carrier for this competitive company immediately placed these 12 cased either on compensation or they were given lump-sum settlement in excess of $50,000. The diagnosis was based upon the clinical and the x-ray examinations, principally the x-ray. There were left 78 cases claiming disability, but their physical and x-ray examinations were negative. Of this group of 78 claiming disability, but without physical or x-ray evidence of asbestosis, 30 came to trial. There is, in our city, the Legal Aid Society which furnishes able counsel for the plaintiffs, as well as competent medical experts. A very capable attorney was chosen for these cases, and the late John B. Hawes, Jr., M.D., as the medical expert. He, in turn, examined these cases both clinically and by x-ray. On these 30 cases he made a positive diagnosis. Under our Statutes of Industrial Diseases of the State of Massachusetts is the so-called "Panel Doctors," a group of three, one of whom is a roentgenologist. Under our State Law their diagnosis is final. They had the opportunity to examine 10 of these 30 cases. Their reports in no instance definitely stated asbestosis, but their findings were reported as, "consistent with," or "a slight degree of," or "the probability of" asbestosis. It was obvious in reading their reports that they were not depending on x-ray findings alone, but were giving the benefit of the doubt to the workmen, in many instances being influenced by the history of exposure. The x-ray films of these cases which were diagnosed as positive by the Panel Doctors, we would have called negative. This illustrates the great difficulty in interpreting an x-ray film, as to the presence or absence of lung changes due to asbestosis. In many instances it is a matter of personal opinion, and the value of an opinion is in a large measure in proportion to the roentgenologist's training and experience in this specialized field.

The late John B. Hawes, Jr., M.D., who was one of our distinguished specialists on tuberculosis, always forcefully expressed his opinion regarding an individual who worked in a dust hazard, claiming that exposure for three years or more made the individual a potential case of asbestosis. He so expressed himself when these cases came to trial. We all felt that at least 80 per cent of his positive diagnoses depended upon history of exposure rather than subjective or objective physical signs.

We will not attempt in this paper to take up the question of physical diagnosis, but we will say that it is our firm conviction that at the present time the only method of positive diagnosis is the x-ray, and that aside from the history of exposure there are no clinical pathognomonic signs of the disease. The clinical facts on which Dr. Hawes based his diagnosis and prognosis of asbestosis were as follows: (1) history of exposure; (2) difficulty in breathing on exertion; (3) cough; (4) rapidity of heart action on exertion, and (5) that asbestosis was a progressive disease, once contracted, whether the individual remained in the industry or was removed.

In addition to these clinical observations of Dr. Hawes, it is interesting to note that in our experience a large number of patients showing a definite x-ray evidence of asbestosis, give a history of coughing up blood. The amount of blood varies considerably, usually no more than blood-streaked sputum, occasionally a substantial amount of pure blood. We have speculated considerably as to the etiology of this symptom. It has been observed for some time that workers in asbestos dust are prone to the development of areas of irritation on the hands. In many instances, these lesions develop into open ulcers which are extremely difficult to heal. Microscopic examination of some of these ulcer bases has demonstrated the presence of asbestos fibers embedded in the deep layers of skin. A total removal of the ulcerative tissue containingt he asbestos fibers results in prompt healing of the lesion. It is not impossible that a somewhat similar condition may develop in the trachea or bronchi of the lungs, with a superficial erosion of the mucous membrane, due to the mechanical irritation of the asbestos fiber, and the symptom of hemorrhage, so commonly observed, is due to small bronchial ulcers.

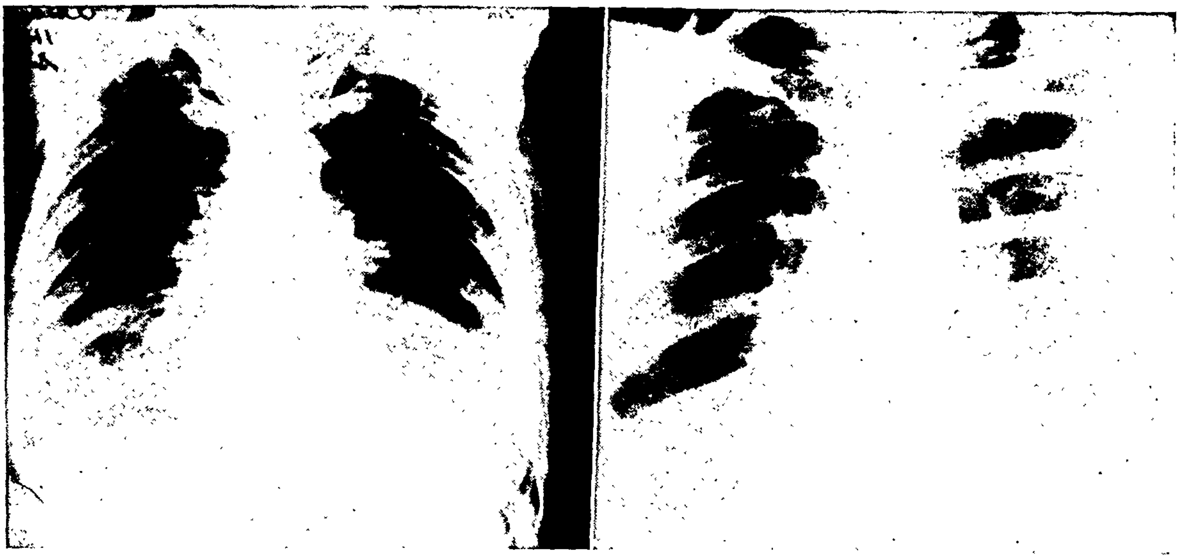

Fig. 1. Fig. 2.

Fig. 1. Case 1. Mrs. A., examined impartially in 1931, was negative; 1936, positive. Intermittent employment from 1919 to 1929, from 1931 to 1934.

Fig. 2. Case 2. Mr. D., more than six years' continuous exposure.

It has also been observed that asbestos dust like silica and some of the other dusts seems to have a selective action. In other words, certain individuals seem sensitive to the asbestos dust and others are immune. It is a very common experience to find two individuals working in the same concentration of dust for the same length of time and same type of work, and only one developing asbestosis; the other remains in perfect health. No satisfactory explanation has been made of this apparent idiosyncrasy. It is possible that the explanation may be a simple one, namely, the method of breathing. The man who habitually breathes through his nose, with all the protective mechanism which Nature has furnished to prevent dust hazard, would have much less chance of developing injury to his lungs than the man who habitually breathes through his mouth and does not receive the benefit of the protective organs of the nose and nasal pharynx.

As a side-light on the question whether or not asbestosis is a progressive disease, I

would now like to refer to the 12 cases previously mentioned, that were diagnosed as positive in 1928 and 1929, given compensation, and discharged. At one of the hearings they were re-called by the insurance company to illustrate that these 12 who had been found positive by both clinical and x-ray examination were, by their own testimony, free of all symptoms, and, except for several women in the group, were doing laborious work in their new occupations. If, according to Dr. Hawes, asbestosis is a progressive disease, once contracted, these individuals should have been in the same condition as in 1928 and 1929, or much worse. It would be logical to assume that eight or nine years away from the industry, without symptoms, gives us very definite evidence that this disease, provided we were correct originally, is not a progressive one, at least in this particular industry.

It is evident that if a history of exposure to asbestos dust is eliminated, a positive clinical diagnosis of asbestosis cannot be made. In other words, there is no one physical finding or group of objective signs which are pathognomonic of asbestosis. We are of the opinion that in x-ray examination we have the best and perhaps the only method of diagnosis of asbestosis at the present time.

The x-ray reveals the actual tissue changes in the lungs. In a general way these changes are much less extensive, as compared with silicosis or anthracosis. We find little parallel between the extent of the visible pathology and the severity of the clinical symptoms. It has been impracticable to classify the disease into different stages. All of our positive cases have shown about the same amount of lung involvement.

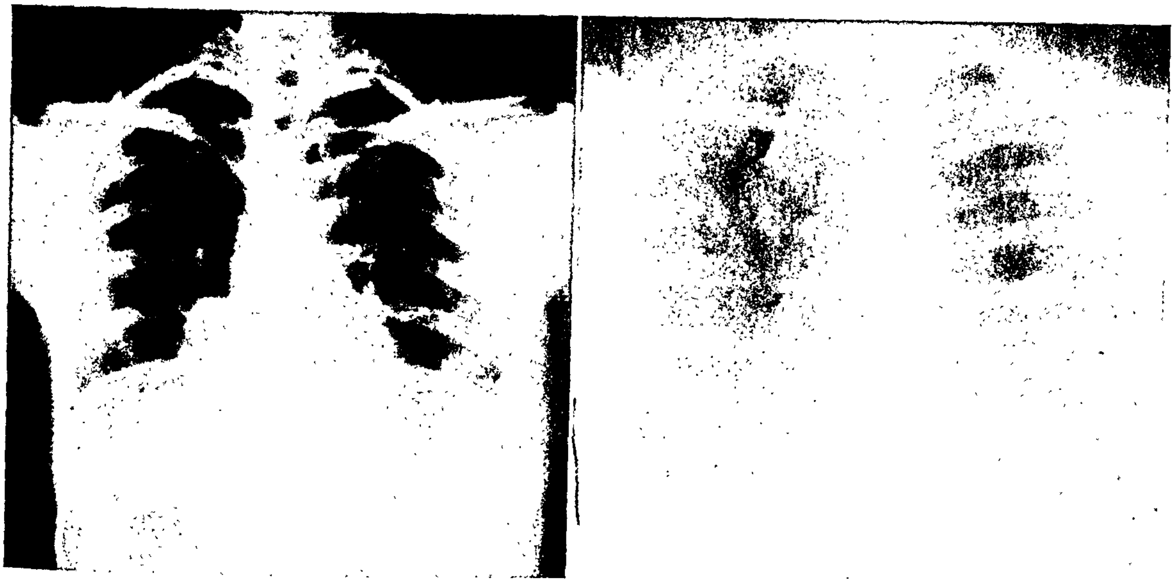

Fig. 3. Fig. 4.

Fig. 3. Case 3. Mr. K., more than six years' intermittent exposure.
Fig. 4. Case 4. Mr. Y., more than six years' exposure.

The theoretical "early" or "incipient" asbestosis, a stage before visible lung changes are present, cannot, of course, be diagnosed by the x-ray. On the other hand, we are of the opinion from our general observations, and it is the opinion of several clinicians who have studied these cases, that asbestos dust will not give symptoms until there has been sufficient lung-tissue change to be visible on an x-ray film. The average uncomplicated case of asbestosis gives rather consistent and characteristic x-ray findings.

In the first place, there is an increased density in the lung-fields. This increased

density is characterized first by bilateral distribution, and, secondly, by its being limited to the lower lobes of both lungs. The quality of the shadow is characterized by a homogeneous quality and is described

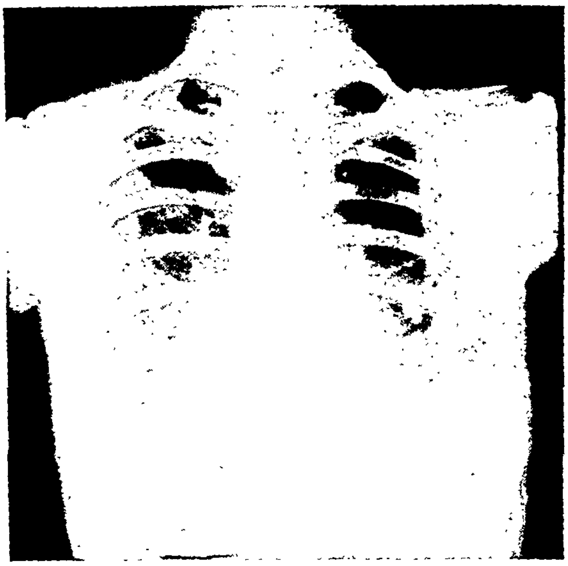

Fig. 5. Case 5. Mr. H., more than six years' exposure.

in the literature as a "ground-glass" or "smoky" appearance. The microscopic changes in the lung show that we are dealing with an almost interstitial fibrosis with areas of atelectasis of the alveoli and smaller bronchioles. There is an absence of the gross nodulation seen in silicosis. What nodulation there is has a fine, evenly distributed quality. There are no characteristic changes about the root shadows. Some cases are associated with hilum fibrosis and glandular enlargement, but many cases of asbestosis show no variation in the appearance of the hilum shadows. Often there is some accentuation of the bronchial shadows. There is frequently found a peculiar appearance of the bronchial tree in both lower lobes, in that it presents a rather laminated appearance. This peculiar arrangement of the bronchial shadows is apparently due to localized areas of emphysema scattered throughout the lower lobes. The microscope tells us that the basic pathologic change is the deposit of a protective element about the asbestos fiber, rather than a destructive process of the lung tissue. The asbestos fibers appear to be surrounded by a substance uniform in character and having the appearance of connective tissues. It would appear from a study of the slides that the fiber is innocent of producing any pathologic disturbance, except an impedance to the air in this region of the lung. In other words, in asbestosis we are dealing primarily with an atelectasis due to the mechanical blocking of the alveoli and bronchioles by the protecting fibers about the asbestos fiber. This peculiar diffuse microscopic fibrosis, associated with atelectasis and microscopic areas of emphysema, is the type of change that produces the so-called "ground-glass" appearance on the x-ray film.

In the second place, asbestos dust produces changes in the pleura, the most constant finding being an accentuation of one or more interlobar pleural septa. The microscope shows that fibrosis associated with the asbestos fibers is prone to involve the pleural covering of the lung. The demonstration of pleuritic adhesions of both lower chests, with obliteration of the costo-phrenic angles, is a rather constant finding in uncomplicated asbestosis.

In the third place, the x-ray shows the usual signs of emphysema. This emphysema, of course, is not pathognomonic of asbestosis but when accompanied by other x-ray indications, can be considered of a confirmatory nature. This evidence of emphysema is best demonstrated by the limited excursion of both diaphragms and the increased radiability of the lung tissue.

In the fourth place, we have noted in the cases of asbestosis certain changes in the contour of the heart shadow which we feel is somewhat causally related to the process in the lungs. Other writers have put considerable emphasis on the dilatation of the right auricle and ventricle, as evidence of asbestosis. It is our opinion that dilatation of the right side of the heart is seen in a higher percentage of asbestosis cases than in other forms of pneumoconio-

sis, particularly silicosis. There is a theoretical possibility that the type of interstitial fibrosis seen with the asbestos dust is such as to produce a mechanical interference with the circulation in the perialveolar capillaries and that this embarrassment in the pulmonary circulation results in some hypertrophy or dilatation of the right side of the heart. We have not observed any demonstrable dilatation of the pulmonary artery.

There are several points which are of importance in the differential diagnosis between asbestosis and other forms of pneumoconiosis, and also between asbestosis and other shadows, due either to faulty technic or to variation in the lung markings from other conditions not connected with the dust hazard. It would seem unnecessary to mention faulty photographic technic. It is our belief that many erroneous x-ray diagnoses of asbestosis have been made on x-ray films which were either under-exposed or over-exposed. The physical qualities of the individual should also be taken into consideration. A woman with large breasts will give an x-ray picture which may have all the characteristics of lung changes due to asbestosis. The fact being, however, this variation in density is due to chest-wall structure, rather than to changes within the chest cavity.

There are certain points of importance in the differential diagnosis of asbestosis and silicosis.

(1) The increased density in asbestosis is confined to the bases; in silicosis it is primarily found in the central portion of both lungs and frequently the bases are clear.

(2) The nodulation of asbestosis is the fine granular-type areas; in silicosis the nodulations are coarse and in the advanced stages they become conglomerate, producing areas of apparent consolidation.

(3) The pleura is more likely to be involved in asbestosis than in silicosis. The same is true of the hypertrophy of the right side of the heart in asbestosis. In our experience this heart condition is rarely seen in silicosis. In this particular industry which we have studied, the percentage of silica, where it was found in the dust tests, was less than 30 per cent, and we have not been bothered by a combination of asbestosis and silicosis. It is conceivable

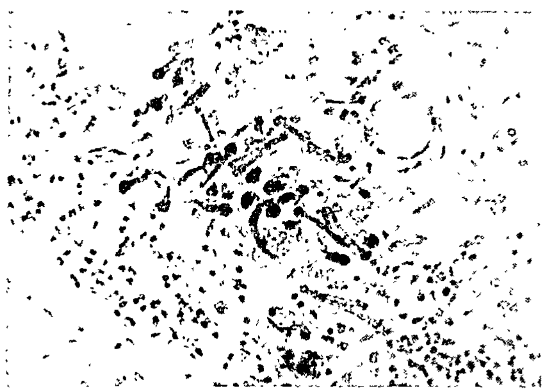

Fig. 6. Photomicrograph of section of lung showing asbestos bodies. (Courtesy of Liberty Mutual Insurance Company.)

in certain industries, and perhaps in the mining of asbestos, we may have a dust hazard of asbestosis with a high percentage of silica. In the advanced cases of pneumoconiosis due to this double hazard, it might be fairly easy to determine from the x-ray the amount of disease due to the silica and that due to the asbestos fiber, but in the average case an accurate interpretation of pneumoconiosis due to both asbestos and silica would be a difficult procedure.

In this series of cases we have found no case of complicating tuberculosis. From our experience we are of the opinion that asbestosis is not prone to the development of tuberculosis, and we have had no case in which there was evidence of asbestosis lighting up a pre-existing tuberculosis. The differential diagnosis between asbestosis and tuberculosis is reasonably easy. The diseases have little in common, as far as their x-ray appearance is concerned. This is not true in cases of silicosis complicated by tuberculosis. It is sometimes difficult to make a differential diagnosis between asbestosis and certain conditions which produce congestion of the lower lobes of the lungs or accentuation of the

bronchial shadows in the lower lobes. Chronic passive congestion associated with heart lesion might well simulate conditions of asbestosis. The differential diagnosis in such an instance depends considerably upon the clinical history. Chronic bronchitis or bronchiectasis might produce a picture somewhat confusing with asbestosis, but neither of these conditions usually shows the characteristic "ground-glass" increased density over the lower lobes.

CONCLUSIONS

(1) It is our opinion that every industry with an asbestosis hazard must be a special study in itself. All asbestos mining and manufacturing cannot be classified in one group as to the dust hazard. The percentage of silica in the asbestos dust must be taken into consideration. The method of manufacturing, whether it is the dry or wet method, is of importance.

(2) We are of the opinion that the disease, asbestosis, is not a progressive disease after the individual has been removed from the dust hazard.

(3) There is no evidence in our study of asbestosis for the past ten years that asbestosis has any causal relation to tuberculosis.

(4) It is our opinion that the final diagnosis of asbestosis must depend mainly on the x-ray evidence, that there are no clinical findings pathognomonic of asbestosis, and that an amount of asbestos dust in the lungs, sufficient to produce symptoms, will give visible evidence of tissue changes on the x-ray film.

ULCER NICHES WITH STOPPER-SHAPED VASCULAR DEFECT[1]

By ÅKE ÅKERLUND, M.D., Director of the X-ray Department of the Maria Hospital, *Stockholm, Sweden*

FOR the past 12 years I have been collecting a small series of ulcer cases with roentgenological niche formation, all presenting a special characteristic and interesting morphological feature which, so far, I have not seen depicted in the roentgen literature. The only reference to this feature which I have seen in the literature is a short—just a few lines—unillustrated contribution to a discussion by H. H. Berg at the German Roentgenological Congress, in Dresden, in April, 1932, after a paper read by H. U. Albrecht on "Roentgen Anatomical Findings in the Digestive Canal in Reference to their Patho-anatomical Substrata."

Fig. 1.

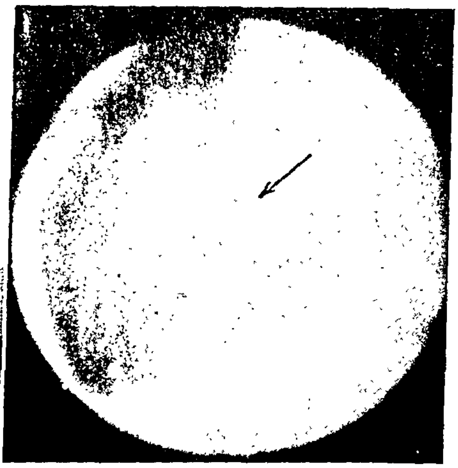

Fig. 2.

Fig. 1. Juxtapyloric gastric ulcer; niche with vascular defect.
Fig. 2. Duodenal ulcer; bulbar niche with central vascular defect.

In the first place, I would like to give an account of my own limited material. It is made up of but six ulcer cases, all with niches: one case of juxtapyloric ulcer of the stomach; three cases of ulcer of the duodenal bulb; a fifth case of ulcer of the descending part of the duodenum, and a sixth case of a peptic jejunal ulcer after resection of the stomach. One of the cases was placed at my disposal by the courtesy of Professor H. H. Berg of Hamburg, and another case was radiographed by Dr. W. Magnusson at Sophiahemmet, in Stockholm, shortly before I was consulted by the surgeon in attendance, operation being considered, as to the interpretation of details in the radiogram.

The interesting feature in the roentgen findings is identical in all the six cases and of typical appearance. In *en face* films, with suitable compression, there is seen *within the niche shadow a circular defect more or less centrally situated and sharply defined* of a thickness of about a knitting-needle or a match. In successful profile films I have sometimes been able to show that the defect is somewhat elongated and *stopper-shaped and that it extends from the bottom of the niche.*

A brief account of the six cases will follow.

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[1] This is one of a series of papers contributed by friends and former pupils of I. Seth Hirsch, M.D.

Fig. 3. Duodenal ulcer; bulbar niche with central vascular defect.

having further abdominal symptoms with severe vomiting. Weber's reaction in feces strongly positive (Fig. 1). Diagnosis, juxtapyloric gastric ulcer with niche formation on the minor curvature; rounded vascular defect in the niche.

Case 2. (Professor H. H. Berg's case, Figure 2.) Recent ulcer of the duodenal bulb without any other deformity than an *en face* niche surrounded by a circular clearer zone. On a compression film, a vascular defect can be clearly seen within the niche.

Case 3. A married woman, 35 years of age, has had recent recurrent duodenal ulcer. Two years ago she suffered a period of epigastralgia, and has been having hunger pains and nightly pains for three or four weeks. There is no melena. An *en face* niche appears in the bulb on compression surrounded by a circular clearer zone; in the niche there is a rounded central vascular defect (Fig. 3).

Fig. 4.

Fig. 5.

Fig. 4. Chronic duodenal ulcer; bulbar niche with vascular defect.

Fig. 5. Chronic ulcer in the descending part of the duodenum; distal niche with vascular defect.

Case 1. Male, aged 66 years. Periodical ulcer symptoms for the past twenty years or so; three or four years ago, tarry stools. For the last few days he had been

Case 4. When operation was being considered, this case was referred to me for consultation by Professor Einar Key. Chronic duodenal ulcer with marked shrink-

ing of the bulb is shown in Figure 4. On its lower side, and just beyond the pylorus, there is a niche the size of a pea, in the center of which there is a well-marked rounded vascular defect.

Case 5. Male, aged 53 years, had had six months ago, and lasting for six weeks, copious hematemesis, the latest hemorrhage occurring in conjunction with persistent severe epigastralgia. A week after ulcer treatment, which was immediately instituted, Weber's reaction was negative in the stools. A distal duodenal ulcer was visible on the concave side of the upper portion of the descending part of the duodenum (Fig. 5). In the niche formation, the size of a coffee bean, there is a constant and distinct vascular defect.

Case 6. Male, aged 35 years, had been having recurrent symptoms of duodenal ulcer for the past 20 years. Three years ago he was operated upon for duodenal ulcer (resection of stomach according to Billroth II). For the past three weeks he has been having nightly epigastric pains. There was emaciation, increasing pallor, and positive Weber's reaction. There was a peptic jejunal ulcer close to the site of the gastro-enterostomy (Fig. 6). In the niche there is a rounded central arterial defect.

Fig. 6 Peptic jejunal ulcer; niche with vascular defect.

For years I have deferred the publication of the report of these cases in the vague hope of getting an opportunity of autopsic confirmation in at least one of them, but, so far, I have in no single case had access to the anatomical specimen in relation to the roentgen examination. It should perhaps also be pointed out that in those cases in which I subsequently, after one or several months or years, had the opportunity of checking the examination, the defect was not found to persist even in those instances in which a niche formation could be demonstrated at about the same place.

Although there is thus no autopsic confirmation of my cases, there would scarcely seem any doubt about the anatomical basis of these roentgen findings. There can be no question of any gas bubble, blood clot, or remaining food residue; as evidence against any of these possibilities, we have the constant central position of the defect in repeated serial films and in different positions of the body, as well as its shape, size, and general appearance in *en face* and profile films. Nor have analyses of pathoanatomical preparations revealed any central stopper-shaped projections of granulations.

The only explanation left, then, is that the defect is caused by a vascular plug projecting from the floor of the ulcer and in his aforementioned statement Berg also briefly related a case of gastric ulcer in which an arterial stump, the size of a grain of rice and protruding from the floor of the ulcer, was considered the likely anatomical basis of the roentgen finding in question.

Most of us probably recall from the illustrations of our pathological textbooks and from pathological specimens the typical appearance of a gastric or duodenal ulcer, into the floor of which we found a rigid and thickened, perhaps aneurysmatic arterial stump, protruding like a stopper into the lumen of the ulcer crater, either thrombosed or eroded (Figs. 7, 8, 9). A film of that nature from Kaufmann's "Special

Pathological Anatomy" and from Hurst and Stewart's monography "Gastric and Duodenal Ulcer," as also a diagram showing the typical roentgen finding in an *en face* and profile film, are shown in Figure 10.

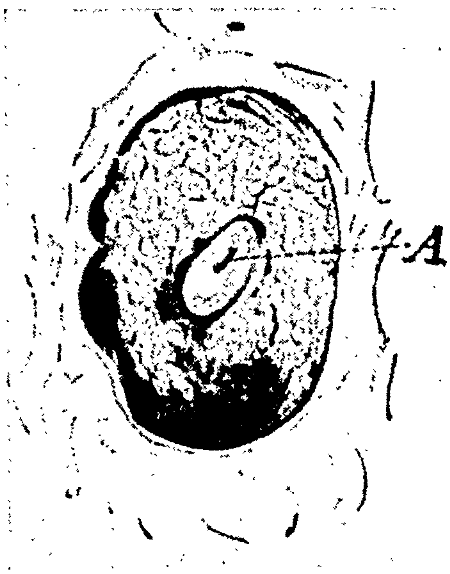
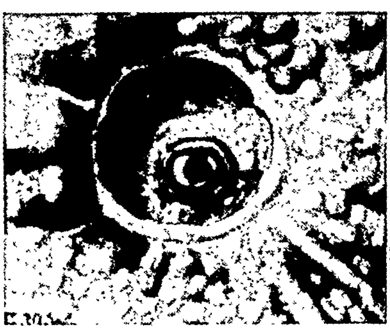


Fig. 7. Fig. 8.

Fig. 7. From "Special Pathological Anatomy," Kaufmann.
Fig. 8. From "Gastric and Duodenal Ulcer," Hurst and Stewart.



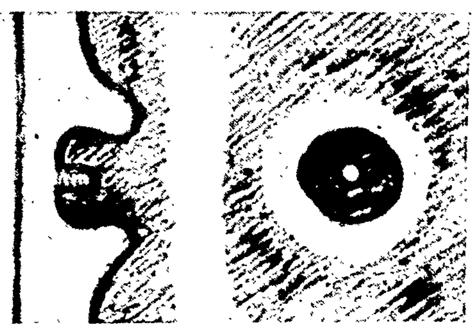


Fig. 9. Fig. 10.

Fig. 9. From "Gastric and Duodenal Ulcer," Hurst and Stewart.
Fig. 10. Diagram showing the roentgen finding: niche with central vascular defect in an *en face* and profile drawing.

Obviously, a roentgen finding of this type must influence our therapeutic handling of the case and urge us to exercise great care in dealing with it. On the other hand, it should be pointed out that but one of the six cases reported herein had had large and repeated hemorrhages, and these had been, fortunately, without fatal issue.

This roentgen finding shows to what point of accuracy and fineness we are able, in favorable cases, to stretch modern roentgenological ulcer diagnosis. In many cases, the result of a roentgenological examination to-day affords us scarcely less information than a scrutinizing examination, by the naked eye, of a patho-anatomical specimen, so far as the abundance of details is concerned.

SUMMARY

Six cases of ulcer with niche formation in the stomach, duodenal bulb, descending duodenum, or jejunum, respectively,

characterized everywhere by a stationary, stopper-shaped, rounded defect in the center of the niche, of the thickness of a knitting-needle or a match, are demonstrated. Although no autopsic verification was available in any of the cases, the author considers himself justified in assuming that the abnormal formation is due to a thickened arterial stump which, in a stopper-shaped manner, projects into the niche from the floor of the ulcer.

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THE BIOLOGY OF BONE METASTASES[1]

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TRANSLATION BY FRANZ J. LUST, M.D., NEW YORK CITY

IT has been definitely established, since Samson, in 1834, described the first case of bone metastasis, that one of the common sites of metastatic deposits of malignant tumors is the skeleton. The bones, liver, and lungs are the most frequent sites of hematogenous metastases, not taking into account the involvement of the regional lymphatic glands through the lymphatic spread.

Skeletal metastases may arise from malignancy of any organ. However, it is a biologic fact that newgrowths of different organs vary in the frequency with which they metastasize to the skeleton. Kitain, from the Lubarsch Institute, in Berlin, found bone metastases in 10 per cent of all cases of carcinoma. On this basis, two types of carcinomas may be distinguished. The first includes carcinomas of those organs in which bone metastases are more frequent, or, at least, as frequent as the average site. The second group consists of carcinomas of those organs in which bone metastases are less frequent than above mentioned. The carcinomas of the first group may be called *ossophile*, and those of the second group *ossophobe.*

In the *ossophile* group are the carcinomas of the prostate, thyroid, breasts, and kidneys. Obviously, we are dealing with organs which have a glandular structure and a cylindrical epithelium.

The *ossophobe* group, also, shows a definite anatomic structure. Squamous-cell epithelium carcinomas, those originating in the skin, mouth, esophagus, and portio uteri, very rarely (only in 1 per cent) produce bone metastases. It is obvious that the histologic structure of the organs in which the primary tumors originate has a definite influence on the frequency of bone metastases.

However, this cannot be the only decisive factor, for there is a large group of carcinomas of the gastro-intestinal tract which do not produce bone metastases more often than do the squamous-cell epithelium carcinomas, in spite of their origin from the cylindrical epithelium.

The biological influencing factor may be that the ossophile carcinomas are usually small. Because of the small size of the primary tumors, it is not unusual to find bone metastases before the primary tumors are detectable. These tumors are so small that they may not be found clinically or roentgenologically. Occasionally, even at autopsy, in spite of the presence of an epithelial bone tumor, which definitely is metastatic, the primary tumor cannot be found.

Most carcinomas of the gastro-intestinal tract, are, however, of considerable size, so that we are often able to feel them and demonstrate them roentgenologically, even though they are deep-seated.

Taking those two facts into consideration, we reach a conclusion which was first proved by Ehrlich. He found in his experiments with mouse carcinomas, that "the percentage of metastases in slow-growing, spontaneous tumors is comparatively much higher than in slow-growing implanted tumors." Ehrlich called this phenomenon "arthreptic immunity."

Summing up, we can say that the ossophile tumors are characterized on the one hand, by the histologic structure of the organ of their origin, and, on the other hand, by a small size at their site of origin. The character of original tissue may be called the constitutional factor, and the size of the tumor, the conditional factor, having a bearing on the origin of a bone metastasis.

[1] This is one of a series of papers contributed by friends and former pupils of I. Seth Hirsch, M.D.

The fact that the skeleton is so often the site of metastases of certain carcinomas is still more remarkable when we consider that the skeleton, lacking an epithelium, can never be the origin of a primary carcinoma. This fact is still more striking, because primary bone tumors, such as sarcomas of the bones, only rarely produce bone metastasis. Those tumors, rather, metastasize into different organs, especially the lungs.

This antagonistic behavior gives us the impression that the ossophile carcinomas are apparently debilitated or not aggressive, so that large tumors are not produced at their site of origin. As these carcinomas are disseminated by the blood stream, they are able to develop only in the skeleton because the bone tissue does not possess an epithelium, and, therefore, is not able to produce a defense mechanism against the foreign epithelial new-growths.

In corroboration of this theory, stands the fact that after metastasizing in the skeleton, other organs, striking as it may seem, may remain a comparatively long time free from metastases. Von Recklinghausen was the first to point out this fact in a case of carcinoma of the prostate in which a general spread of the carcinoma was found in the bony system, but not in the soft tissues. This fact has been emphasized repeatedly in carcinomas of different origin. The frequency of bone metastases as compared to simultaneous visceral metastases varies with different types of carcinomas. It is, however, a fact that patients with lung metastases only occasionally show bone metastases and, *vice versa*, patients after having widespread metastases in the skeleton, are free from lung metastases for a long time, even as long as they live.

The general fact that only slow-growing carcinomas of certain histologic structure metastasize to bone without affecting the viscera, may be called the first fundamental principle of the biology of bone metastases.

The second fundamental principle is that different parts of the skeleton differ in frequency as to the site of metastases, the most frequently affected being the spine, particularly the lumbar vertebræ, the dorsal vertebræ, the pelvis, and the adjacent parts of the femur are next in frequency. All the other parts of the skeleton are not so frequently affected; this is especially true of the extremities. The behavior of bone metastases differs in this from the behavior of the primary bone sarcoma, which is most often found in the extremities, whereas it but seldom develops in the spine or the pelvis.

The fact that the lumbar vertebræ and the pelvis are most frequently involved by metastases, suggested to Von Recklinghausen that the metastases are implanted in such parts of the skeleton as are exposed to the greatest pressure. Were this a decisive factor, metastases would not be found only in the lumbar vertebræ and in the pelvis, but as frequently in the bones of the lower extremities and especially in those of the legs and feet, for there is probably no part of the body which is more subjected to the effects of weight-bearing than the feet. As already mentioned, it is an exceedingly interesting fact that the lower extremities, from the knees down, are practically free from metastases, and these are but rarely found in the upper extremities distal to the elbow joint. Below the knee and elbow joints, metastases are extremely uncommon. Consequently, it is not the greater static, but rather the less dynamic usage which predisposes to the development of bone metastases. In parts of the skeleton which are less used dynamically as, for instance, the spine, there are apparently better conditions for retention of the carcinoma cells which are brought to it through the blood stream. In the less used parts of the skeleton the blood stream is slower, and permits easier retention in the bone marrow to which the tumor cells are carried by the blood stream.

Of further biologic interest is the fact that bone metastases develop infrequently in the cortex, but more often in the spongiosa, so that most of the bone metastases begin as bone marrow metastasis.

The tumor tissue which intrudes into the bone usually causes dissolution and progressive disappearance of the portion involved. We, therefore, speak of an osteolytic (osteoclastic) effect of the bone metastases. It is known since Von Recklinghausen's first description that in the neighborhood of a bone metastasis a formation of new bone tissue is occasionally seen which is called osteosclerotic (osteoplastic) bone metastases.

The fact that the dynamically less used parts of the skeleton, such as the spinal column, are much more frequently the site of metastases than the extremities, is also demonstrated by the varying frequency of the osteoplastic and osteolytic metastases.

Osteoplastic metastases are more common than the osteolytic in parts of the skeleton which are less used and are still less common than the osteolytic metastases in bones which are more dynamically used. Therefore, as frequently as osteoplastic metastases are found in the spinal column or the pelvis, so rarely can they be demonstrated in the extremities or the skull. The difference is such that in the same case different types of metastases are found in different parts of the skeleton. For instance, in carcinoma of the prostate gland, while the pelvis and the spinal column contain osteoplastic metastases, the skull or the humerus may be destroyed by osteolytic foci.

We were able to show that the osteoplastic character of a metastasis is influenced, first, by the *site of the primary tumor;* second, by the *site of the metastasis.* A further factor may be the *scirrhous character of the primary tumor*, as often seen in carcinoma of the breast. This fact is easy to understand, as the formation of bone does not originate from the tumor cells but from the stroma of the carcinoma, and as the latter invades the endosteum, for the scirrhous character of a tumor shows the constitutional ability of the individual to form considerable carcinomatous stroma. These are fundamental for the development of an osteoplastic metastases. A further etiologic factor is the traumatic separation of the continuity of the bone. Spontaneous fractures are not infrequently found in cases of metastases in the extremities. It is a well-known fact that pathologic fractures in cases of metastases have a definite tendency toward spontaneous healing. These fusions often appear clinically, as a spontaneous healing of the carinoma. As a rule, the roentgenogram shows the continued existence of carcinomatous destruction. Erdheim has proved this fact histologically. Therefore, the frequent consolidation of a spontaneous fracture in a case with metastases in the skeleton is not a healing of the carcinoma, but only an osteoplastic carcinoma reaction caused by the trauma. The carcinoma cells do not disintegrate but there is bone formation originating from the connective tissue of the carcinomatous stroma which adapts itself to those changes produced by the trauma and consequently has the appearance of callus. Definite osteoplastic reaction in bone metastases is seen after x-ray treatment. This reaction is especially marked in instances in which there is an original tendency to osteoplasia, particularly in tumors of the scirrhous type. A considerable new formation of bone, after roentgen treatment of purely osteolytic metastases, may occur in cases of carcinomas especially sensitive to the rays, as, for instance, in carcinoma simplex. Metastases of such type may be entirely destroyed so that the consequent osteoplastic reaction means a *restitution ad integrum.*

The fact that some tumors more frequently produce osteolytic and others, more frequently osteoplastic metastasis, has a practical significance in roentgen diagnosis. On this basis, we are able to differentiate certain roentgenologic types of bone metastases. Thus, it is possible to distinguish:

(*A*) Metastases of a purely osteolytic type (*tabula rasa*, Kienböck; *spotty type*, Hintze). These are most frequently found in carcinoma of the kidneys. The bone

substance looks as if dissolved by chemical agents, producing widespread defects which have no definite form, the whole cross-section of the bone being destroyed and the bone substance having definitely disappeared.

(*B*) Metastases of the osteolytic type, with shell formation (*cystic type*, Kienböck; *soap bubble*, Schintz). This type most frequently results from carcinoma of the thyroid gland. In these cases, only the inner part of the bone is dissolved, as in metastases from kidney carcinoma, while the cortical border of the bone remains intact for some time, so that there is a shell formation around the tumor. However, bone trabeculæ may sometimes still be present inside of the bone, thus producing a honeycomb appearance. There is still another type of osteolytic metastases, in which only the border of the bone disappears while the remainder of the bone continues intact. This erosive form is found in different bone tumors and has, therefore, no differential diagnostic significance.

(*C*) Metastases of a purely osteoplastic type (ivory or marble bones). These are most frequently found in carcinomas of the prostate. In these cases, the bone marrow becomes filled with new bone so that the total density of the bone is increased without any change in the shape and contour of the involved bone.

(*D*) Metastases of the osteoplastic type with islands of increased density. They are most frequently seen in carcinomas of the breast. Only parts of the bone become sclerotic. Those sclerotic parts in the spongiosa resemble islands of compacta. The form of the diseased bone remains unchanged.

(*E*) Metastases of the mixed type (the tiger-skin type). This type also most frequently results from carcinoma of the breast. The mixed type is found in two different forms. In the one form, there are areas in the center which are osteolytic, while the peripheral parts are dense. In the other form, different parts of the skeleton, for instance, the vertebræ, are osteolytic, while the neighboring parts are osteoplastic. In the osteolytic parts of the bone, the outward form is very definitely changed, whereas in the osteoplastic parts the form is still preserved.

The metastases of the four organs (breast, prostate, kidneys, and thyroid) show certain differences. The bone metastases in breast and prostate carcinoma constitute one group. The bone metastases in kidneys and thyroid carcinoma constitute the other group.

The bone metastases of the first group are usually (prostatic) or very often (mammary) of the osteoplastic type, while this is extremely rare in the second group, which is nearly always osteolytic.

The skeletal metastases in breast and prostate carcinoma most frequently involve the spinal column and pelvis. In kidney and thyroid carcinoma, however, the extremities are relatively frequent sites of the metastases.

The bone metastases of the first group are usually multiple, and not rarely generalized. Very frequently, however, the kidney and thyroid metastases in the skeleton are solitary.

In breast and prostate carcinoma, the finding of bone and lung metastases at the same time s much less common than in kidney and thyroid carcinoma, or, if bone metastases are present, lung metastases develop much later in the first group than in the second.

The bone metastases of the rest of the carcinomas have no special features. As they are quite uncommon, we do not know much regarding their roentgenologic behavior, but they are apparently on the whole of the osteolytic type. This process may lead to a complete absorption of bone or to destruction of the contour, even to expansion of the bone. Osteoplastic bone metastases apparently develop seldom.

The above-mentioned facts regarding the biology of the bone metastases have points of practical significance. These are:

(1) Qualitative: osteolysis or osteosclerosis.

(2) Quantitative: extension of the diseased part.

(3) Topical: site of the metastasis, part of the skeleton and part of the bone, as well as behavior of other organs.

(4) Numerical: solitary, multiple, generalized.

SUMMARY

1. Carcinomas of certain histologic structure, such as squamous-cell epitheliomas, produce only few bone metastases and therefore should be called *ossophobe*. Cylindrical epitheliomas, on the contrary, produce bone metastases more frequently and therefore should be called *ossophile*.

2. Beside the histologic structure, the rapidity of growth and the site of the primary tumor are the determining factors for the frequency of bone metastases. Slow-growing, therefore small, tumors produce extensive bone metastases much more frequently than rapidly growing tumors.

3. Different parts of the skeleton differ in frequency as to the site of metastases, and the less dynamically used a portion of the skeleton is, the more often it is the site of the metastasis. Therefore, the lumbar vertebræ and the pelvis show bone metastases most frequently, whereas the forearms and legs are rarely sites of metastases.

4. Whether the bone metastases are osteolytic or osteoplastic is determined by the site of the primary tumor, the site of the metastases, the connective tissue content of the primary tumor, as well as a contributing trauma.

5. Taking these facts into consideration, we are able to determine, to a certain degree, the site of the primary tumor. Especially metastases from carcinomas of the thyroid, prostate gland, kidneys, and breast very often show characteristic signs which may be determined roentgenologically.

FURTHER NOTES CONCERNING TRAUMATIC SUBDURAL HEMATOMA[1]

By SIDNEY W. GROSS, M.D., *New York City*

THE relation of trauma to subdural hematoma was not clearly indicated until the contribution of Trotter (1) in 1914. The cerebral veins entering the lacunæ of the longitudinal sinuses are extremely thin-walled, unsupported, short, and without tortuosity. The ends of these unsupported portions of the veins are fixed to the rigid dural sinus, while the other ends are attached to the movable cerebral hemisphere. An injury to the head resulting from the application of a force to the frontal or occipital region produces a movement of the brain without any marked alteration in the position of the dura. This may result in a tear in a cerebral vein, usually at its rigid attachment to the longitudinal sinus.

This portion of the vein is extra-arachnoid, so that bleeding occurs into the space between the arachnoid and the dura—the subdural space. Absorption does not take place in the subdural space, so that the clot becomes rapidly encysted. The surface of the clot nearest the dura becomes covered by a layer of fibroblasts and connective tissue, forming a membrane from 1 to 5 mm. in thickness. The surface of the clot adjacent to the arachnoid becomes covered by a layer of arachnoidal cells of transparent thinness. The cyst then increases in size by osmosis, as described by Gardner (2), and probably also as the result of new bleeding from the many capillaries in the outer neo-membrane.

The following abstracts will illustrate the variations in the signs and symptoms which were found in a group of 12 cases.

Case 1. Colored female, 48 years of age, admitted to the hospital Feb. 5, 1935. On admission she was stuporous and a history was not available. Both eyes were deviated to the right, there was a right hemiparesis with a positive right Babinski. The left pupil was larger than the right, and both reacted poorly to light. The nasal margins of both optic discs were blurred. Pulse rate was 60, and blood pressure 160/100. X-ray examination of the skull was negative. Twelve hours after admission the stupor had increased to deep coma. Spinal puncture yielded a clear colorless fluid under slightly increased pressure, and which showed ten lymphocytes per centimeter and a slight increase in globulin. Bilateral trephine exploration in the fronto-temporal regions was done. A large subdural hematoma containing yellowish syrupy fluid was found. Following its evacuation the patient made an uneventful recovery. After her operation the patient gave a history of having received a fist blow to the head five weeks previously.

Case 2. White male, waiter, aged 25 years, was admitted on Dec. 20, 1934, because of occipital headaches, vomiting, and failing vision. One month previously he had received a blow to the jaw and was "knocked out" for a few minutes. However, he continued at work for 12 days, when severe occipital headaches forced him to stop.

Examination revealed bilateral papilledema and a slight right central facial weakness. Cerebro-spinal fluid obtained by lumbar tap was clear and colorless and under a pressure of 50 mm. of water. Plain x-rays of the skull were negative. However, x-rays taken after the injection of air by ventricular puncture showed a shift of the entire ventricular system to the right. In addition, the body of the left lateral ventricle was depressed (Fig. 1). A left parietal craniotomy disclosed a typical subdural hematoma, and its removal was followed by rapid and complete recovery.

[1] This is one of a series of papers contributed by friends and former pupils of I. Seth Hirsch, M.D.

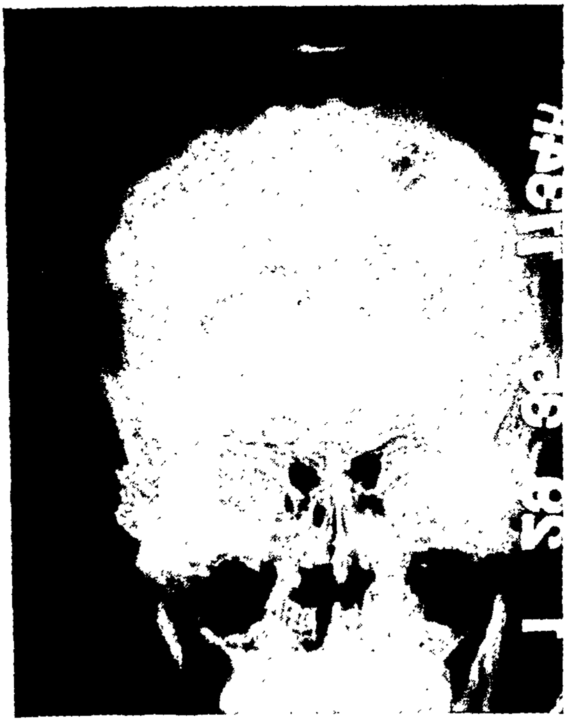

Fig. 1. Case 2. Showing displacement of the entire ventricular system to the right, and depression of the body of the left lateral ventricle.

Case 3. White male, aged 45 years, admitted in coma, March 12, 1936. Two weeks before he had been kicked in the head during a brawl. Following this, he became confused and incoherent, and a few days later very drowsy. When roused, he complained of severe right frontal headache. The day before admission the patient became deeply comatose, and remained so. On admission, his pulse rate was 50. The upper extremities were both spastic, and the Babinski sign was positive on both sides. Lumbar puncture yielded a clear colorless fluid under a pressure of 180 mm. of water. While in the hospital the patient had a convulsion involving the right upper extremity, accompanied by turning of the head and eyes to the right. The right pupil became larger than the left. Consent for operation was withheld for 24 hours. During this interval several convulsions occurred. At operation, a large, well encapsulated subdural hematoma was found and removed. The patient did not rouse from his coma and expired 48 hours later.

Case 4. White male, roofer, aged 44 years, received a blow to the head. He was unconscious for an unknown period, but returned to work the next morning. Two weeks later he had a sudden attack of dizziness and headache. After three days in bed he felt well again, but when he attempted to return to work the headache reappeared and he vomited several times. When examined three weeks after his head injury he was very drowsy, the pulse rate was 40, and there was a left central facial weakness and increase in the tendon reflexes of the left upper extremity. Blood pressure was 140/80. The spinal fluid was clear and colorless and under a pressure of 140 mm. of water. At operation, an encapsulated subdural hematoma, containing a chocolate-colored fluid, was found on the right side. The patient's headache was relieved at once and he made a rapid recovery.

Case 5. White female, aged 49 years, who struck her head three days previously while under the influence of alcohol. She was unconscious for a brief period at that time, but seemed to have suffered no serious injury until three days later when she became drowsy and confused. When examined in the hospital, she had a slightly stiff neck, and her pupils reacted sluggishly to light. The pulse rate was 64 and the blood pressure 162/110. Spinal puncture yielded a xanthochromic fluid under a pressure of 70 mm. of water. Seven days after her injury the patient had a Jacksonian seizure involving the right side of the face and the right upper and lower extremities. Following this episode, stupor deepened and the reflexes on the left side were increased. There was a positive left Babinski. X-ray examination of the skull revealed a linear fracture in the right temporal region. At operation, a large subdural hematoma containing a currant-jelly clot was found on the left side. The patient did not improve, and died 24 hours later.

Case 6. White male, aged 52 years, was struck by an automobile while intoxicated, and brought to the hospital in coma, bleed-

ing from the left ear. The reflexes were absent and a weakness of the left side was evident. The patient improved slowly until the eighth day after his injury when he became more drowsy, the left hemiparesis increased, and the Babinski sign became positive on both sides. The spinal fluid was bloody and under increased pressure. X-ray examination of the skull was negative. Bilateral trephine exploration was done. A right subdural hematoma was found and evacuated. This was followed by a rapid return of power in the left upper and lower extremities, and the patient left the hospital four weeks after the operation in good condition.

Case 7. White male, aged 38 years, was admitted to the hospital in deep coma. He was said to have been in a fight two weeks previously: he became comatose the day before admission to the hospital. On examination, the pulse varied from 56 to 60 per minute. The right pupil was dilated and fixed to light. There was a left hemiparesis, with a left positive Babinski. The optic discs were normal. Spinal tap yielded a clear fluid. The pressure was 260 mm. of water. At operation, a large subdural hematoma containing fluid and clot was found on the right side. There was no improvement following this procedure, and the patient died 24 hours later.

Case 8. White male, aged 52 years, was brought to the hospital in stupor. One month previously, while intoxicated, he fell to the sidewalk and was unconscious for several hours. This was followed by headache and vomiting of one day's duration, and a generalized convulsion followed by stupor. On admission, the patient was stuporous, but could be roused for short intervals to answer questions. His pulse rate was 66 and blood pressure 140/110. Bilateral early papilledema was found. There was also a left central facial weakness and a left hyper-reflexia. X-ray examination of the skull was negative. At operation, a right subdural hematoma was found and evacuated. The patient did not improve and expired 12 hours after the operation.

Case 9. White male, aged 14 years, fainted while in the bathtub. In falling, he struck his head against the side of the tub. Following this he complained of a dull pain over the left eye. Within a few weeks the pain increased in severity and was accompanied by spells of drowsiness. Two weeks before coming to the hospital the patient had diplopia, blurring of vision, and tingling in the fingers of the left hand. On admission, he was alert and well oriented. Bilateral papilledema of four to five diopers was present, along with a slight left external rectus palsy. The spinal fluid was clear, colorless, and under a pressure of 380 mm. of water. The patient was suspected of having a cerebral neoplasm. Frontal ventriculography failed to visualize the cerebral ventricles. Encephalography showed a displacement of the entire ventricular system to the right. The body of the left ventricle was depressed and its normal curved contour flattened. Trephine exploration revealed a left subdural hematoma. Following operation, the papilledema receded, and the patient returned to school, but he continued to have occasional headaches.

Case 10. White male, aged 44 years, was admitted to the hospital in deep coma. Two months previously he began having severe headaches, accompanied by vomiting. After two weeks he was forced to quit his job as a chef, he gradually became more and more lethargic, and his memory became markedly impaired. A few days before admission he became very drowsy, and finally comatose. Except for the deep coma, the neurological examination was essentially negative. The fundi were normal. Spinal tap yielded a clear colorless fluid under a pressure of 110 mm. of water. The pulse rate varied between 50 and 60. Frontal ventriculography was done, but the ventricles failed to fill properly. Lumbar encephalography was likewise unsatisfactory. Bilateral posterior parietal trephine exploration disclosed a bilateral subdural hematoma. Operation was followed

TABLE I.—SUMMARY OF FINDINGS

Case	Injury	Onset of Symptoms	Time of Operation	Headache	Stupor	Pupils	Fundi	Focal Signs	Pulse Rate	Spinal Fluid	Spinal Fluid Pressure	X-ray of Skull	Side of Lesion	Result
1, f., 48	Fist blow to head	Unknown	5 weeks	Not known	Marked	Left dilated	Discs blurred	Right hemiparesis	60	Clear and colorless	Slightly increased	Negative	Right	Cured
2, m., 25	Struck on jaw	12 days later	7 weeks	Severe	None	Normal	Choked discs	None	80	Clear and colorless	500 mm. of water	L. ventricle displaced	Left	Cured
3, m., 45	Kicked in head	Immediate	2 weeks	Severe	Deep coma	Right dilated	Normal	Right side spastic	50	Clear and colorless	180 mm. of water	Negative	Left	Died
4, m., 44	Blow to head	2 weeks	3 weeks	Severe	Marked	Normal	Discs blurred	Left hemiplegia	40	Clear and colorless	140 mm. of water	Negative	Right	Cured
5, f., 49	Fell on head	3 days	8 days	Not known	Marked	Normal	Normal	Reflexes increased on left	64	Xantho-chromic	70 mm. of water	R. temporal fracture	Left	Died
6, m., 52	Struck by auto	Immediate	8 days	None noted	Marked	Normal	Normal	Left hemiplegia	72	Bloody	Slightly increased	Negative	Right	Cured
7, m., 38	Fist fight	Not known	2 weeks	Not known	Marked	Right dilated	Normal	Left hemiparesis	56	Clear and colorless	260 mm. of water	Negative	Right	Died
8, m., 52	Fell to sidewalk	1 week	4 weeks	Marked	Marked	Normal	Early choking	Reflexes on left increased	66	Xantho-chromic	Slightly increased	Negative	Right	Died
9, m., 14	Fell in bathtub	Immediate	3 months	Moderate	None	Normal	Choked discs	None	72	Clear and colorless	380 mm. of water	Ventricular shift to R.	Left	Cured
10, m., 44	Not known	Not known	2 months	Marked	Deep coma	Small equal	Normal	None	50	Clear and colorless	110 mm. of water	Negative	Bilat-eral	Cured
11, f., 50	Fell down stairs	9 days	9 days	Moderate	Marked	Left large	Normal	Left hemiparesis	100	Xantho-chromic	Increased	R. temporal fracture	Left	Cured
12, f., 42	Struck by auto	4 days	17 days	Moderate	Marked	Right dilated	Normal	Left hemiparesis	56	Xantho-chromic	80 mm. of water	Negative	Right	Cured

by rapid recovery, although during the first few days the patient was markedly confused and disoriented. He eventually cleared up entirely, and, when examined at the time of discharge, he was fully oriented and seemed normal mentally.

Case 11. White female, aged 50 years, who, after falling down a flight of stairs, was unconscious for an hour. She was removed to a hospital, where bleeding from the right ear was noted, and an x-ray examination of the skull disclosed a fracture in the right temporal region extending into the base of the skull. There was a right peripheral facial weakness at this time. The patient improved rapidly and was thought to be well on the way to recovery, when, on the ninth day post-trauma, she became comatose. Examination at this time revealed a peripheral right facial weakness, a left spastic hemiparesis, bilateral Babinski, sluggish pupils with the left somewhat larger than the right. The pulse rate was 100. Spinal fluid was tinged yellow, and the pressure, though not measured, was reported as "elevated." Bilateral fronto-temporal trephine exploration revealed a left encapsulated subdural hematoma containing a large amount of chocolate-colored fluid and some solid clot. The patient awoke from her coma on the operating table, and made a rapid recovery.

Case 12. White female, aged 42 years, was struck down by an automobile and removed to the hospital. She had a laceration in the right frontal region which was sutured. A spinal puncture done soon after the injury yielded a bloody fluid which was under a pressure of 110 mm. of water. She rapidly recovered from the immediate effects of the injury and seemed well on the way to recovery. After four days she began to complain of headaches. On the fifteenth day after the injury she became stuporous. Her pulse was slow, there was a weakness of the left upper and lower extremities, and a positive Babinski on the right. The fundi were normal. A spinal tap at this time gave a yellow, clear fluid. The pressure was 110 mm. Bilateral temporo-frontal trepination was done. An encysted subdural hematoma was found on the right side. After its evacuation the patient made a rapid and uneventful recovery.

DISCUSSION

Many reports (3,4,5) concerning traumatic subdural hematoma have appeared in recent years so that typical cases rarely escape detection. However, variations in the clinical picture have not been stressed and misconceptions concerning the importance of some of the signs and symptoms are prevalent.

In this series, four of the twelve patients were female. The average age was 38 years, the youngest patient was 14, the oldest 52. Most of the patients received direct blows to the head. In one case there was no history of an accident. Five were injured in fights, one fell in the bathtub, one fell to the sidewalk, two fell downstairs, and two were pedestrians who were struck down by automobiles. In only three cases was the injured person considered so seriously traumatized at the time of the accident that he was removed to a hospital. In the other cases, hospitalization was not considered necessary until several days or weeks later. The earliest operation was done eight days after the known injury: an average of about three and one-half weeks elapsed from the date of the accident to the time of operation: the longest interval was three months. In one case, in which a history of trauma was not obtained, operation was done two months after the onset of symptoms. In every case but one, in which it was possible to obtain a history, headache was present. In three cases no history was available. Alteration in the state of consciousness was present in 10 of the 12 cases. The four patients who died were in profound coma at the time of operation. Six were in stupor, but could be roused slightly on painful stimuli: two had no alteration in the state of consciousness. Convulsive seizures could be attributed to the lesion in only one case. In another

patient who had frequent seizures while under observation there was a long-standing history of convulsions, while a third who had convulsions was a chronic alcoholic of many years' duration.

In eight of the 12 cases the pulse rate was abnormally slow: the remaining four had normal rates. There were no constant alterations of blood pressure, which in most cases was within normal limits. In three patients a dilated pupil was found on the side of the lesion, while two had the large pupil on the normal side. In seven cases the pupils were equal in size. In six cases hemiplegia and increase in reflexes were found contralateral to the lesion, and were of aid in localization. In three cases a hemiplegia was found on the side of the lesion. In the remaining cases the reflexes were equal.

Two patients had severe papilledema at the time of admission and were at first suspected of having brain tumors. One patient who was deeply comatose on admission had early papilledema. In two cases the disc margins were blurred, and in the remaining seven the fundi were normal.

The cerebrospinal fluid was clear and colorless in seven cases; in four it was xanthochromic, and bloody in one. The pressure was determined with a water manometer in eight patients: in four it was 180 mm. or higher; in four, less than 180 mm., and in the remaining four, in which a manometer was not used, it was estimated as "increased" or "slightly increased."

The subdural hematoma was on the right side in six cases, on the left in five, and bilateral in one. X-ray examination of the skull was normal in ten cases. In the remaining two, right temporal fractures were found. Ventriculography was employed on three occasions and encephalography twice in three patients in whom the diagnosis was in doubt. In one case satisfactory ventricular filling was obtained after unilateral occipital puncture. In another, bilateral frontal ventriculography was unsuccessful, but satisfactory ventricular filling was obtained by encephalography. In a third case in which airograms were deemed necessary for diagnosis, both frontal ventriculography and encephalography failed. When burr holes were made in the posterior parietal regions for the purpose of injecting air into the ventricles, a bilateral subdural hematoma was found and air injection was obviated.

In the two cases in which satisfactory ventricular filling was obtained, both showed displacement of the ventricular system to the opposite side and flattening and depression of the body of the ventricle on the side of the lesion.

CONCLUSION

The diversity of signs and symptoms in this series indicates the futility of attempting to formulate a rigid clinical syndrome describing subdural hematoma. X-ray examinations of the skull are most often negative in patients with subdural hematomas. While the diagnosis most often depends on trephine exploration, in some cases ventriculography may be necessary. Occasionally it is difficult to secure filling of the ventricles either by the ventricular or lumbar routes. Films taken after successful ventricular filling show a displacement of the ventricular system away from the lesion and a depression and loss of the rounded contour of the body of the ventricle on the side of the lesion.

It is evident that subdural hematoma must be given a prominent place in the consideration of every patient admitted to the hospital in coma, especially if a history of antecedent trauma to the head is obtained. If, in addition, the pulse rate is slow, and other causes such as diabetes, uremia, and poisoning have been eliminated, exploration for a subdural hematoma is urged.

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ANEURYSM OF THE PULMONARY ARTERY[1]

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AS Edens (1) says, in his classical work about heart disease, aneurysm of the pulmonary artery was mentioned by Morgagni (2), and yet most of our modern textbooks contain only brief mention of this interesting disease.

The few cases described in the literature are repeatedly collected and critically judged. Studying these reports, we must confess that only very few of the reported cases are contributing much about the cause, development, and clinical picture of pulmonary aneurysm. Either the history or the clinical data are missing in many of these descriptions.

First of all, it is necessary to distinguish between the *aneurysm*—the sac-like dilatation *of a part of the pulmonary artery*—and the *multiple dilatations of large arteries of the lungs*. These diverticulum-like dilatations do not seem to be rare, but clinically they do not lead to important symptoms. A third group, which must be separated from the others, is the *diffuse dilatation of the truncus arteriæ pulmonalis*, seen in the x-ray film as a bulging of the pulmonary arch of the heart shadow. We find it frequently in cases of a patent ductus Botalli, in cases of stasis in the pulmonary circulatory tract, especially in cases of mitral stenosis, in cases of insufficiency of the pulmonary valves, and, infrequently, in cases of congenital stenosis of the pulmonary valves. Films of such cases may be seen in the writer's various publications (3, 4, and 5), and in Maude E. Abbott's Atlas of Congenital Heart Disease (40). This diffuse dilatation of the pulmonary artery may be compared with the diffuse dilatation of the aorta which we find regularly in cases of insufficiency, but also occasionally in cases of stenosis of the valves of the aorta.

Medical literature does not give us this threefold division—aneurysm, diffuse dilatation of the arteria pulmonalis communis, and multiple dilatations of the arteriæ pulmonales—therefore, the *exact number of thus-far-published cases* of true aneurysms can hardly be estimated. The fact is that less than one hundred cases were mentioned under this diagnosis within the last one hundred years. Henschen (6) collected 46 cases up to 1906, Posselt (7) collected 26 more up to 1909, Käppeli (8) added 21 in 1933, and since then Esser (9) has reported one case and B. S. Oppenheim (39) seven cases. But, as mentioned before, *only a few of these cases seem to be real aneurysms.*

Roentgenologically examined cases are described by Weinberger (10), Horn (11), Balaban (12), Rosenfeld (13), Spitzer (14), Hoffmann (15), Poinso (16), Kranz (17), Käppeli in collaboration with Lüdin (18), B. S. Oppenheim (39), and some others, perhaps, but only five of these cases (Poinso, Kranz, Weinberger, Käppeli-Lüdin, and Oppenheim) were verified by autopsy.

The rarity of this disease, which could never be overlooked anatomically, can obviously be seen in the fact that Costa (19) found only one case among 2,000 autopsies and Käppeli only one among 8,000. It appears that there are about four aneurysms of the pulmonalis compared to 1,000 aneurysms of the aorta.

As mentioned before, the reports in the literature about the patients with pulmonary aneurysms are so incomplete that we can hardly come to a definite conclusion about the genesis.

According to Boldero (20), sclerotic and, first of all, inflammatory changes very seldom are causal factors, because inflammatory processes are seldom in the region of the pulmonary arteries, due to the venosity of the blood.

[1] This is one of a series of papers contributed by friends and former pupils of I. Seth Hirsch, M.D.

On the other hand, syphilitic changes more frequently seem to be the cause of aneurysms in the pulmonary arteries. But, at the same time, we must consider that syphilis of the arteriæ pulmonalis is a comparatively rare occurrence.

Most of the authors assume congenital alterations of the vessel as a primary cause of the aneurysm of the pulmonary aorta. B. S. Oppenheim (39), for instance, reported about seven cases of congenital hypoplasia of the vessel walls. Here, too, we must mention that, for instance, cases with a persisting ductus Botalli are included under the classification of aneurysm of the pulmonary artery.

The increased pressure in the vessel is mentioned as a frequent cause; and here, again, the cases of mitral stenosis, etc., are included.

But on one point most of the authors agree; it seems almost always necessary for two causal factors to coincide to cause the formation of an aneurysm.

So we may, with Käppeli, list the cases described in the literature in the following way, but once more we must mention that many of these cases cannot be accepted as real aneurysms.

I. Congenital anomalies of the vessels
   1. Patent ductus Botalli (Krzyszkowski, 21; Hoffmann, 15; Kranz, 17; Horn, 11; Moench, 22; Lexow, 23; Groedel, 3, 4, and 5; Abbott, 40).
   2. Unequal division of the truncus arteriosus communis.
   3. Congenital narrowness of the small pulmonary arteries.
   4. Malformations, especially hypoplasia, of the walls of the vessels (Costa, 19; Esser, 9, and B. S. Oppenheim, 39).

II. Hypertension in the pulmonary circulatory system
   1. Valvular diseases, especially mitral stenosis and (Dlauhy, 24; Gilewski, 25; Conti, 26; Spitzer, 14, and Groedel, 3, 4, and 5).
   2. Defect of the septum (Baumgartner, 27).
   3. Perforation of an aortic aneurysm into the arteria pulmonalis (Weinberger, 10).
   4. Cirrhotic processes in the lungs, emphysema, tumors (Storch, 28; Ducach, 29; Dlauhy, 24, and Conti, 26).
   5. Stenosis of the pulmonary vessels (Lissauer, 30).
   6. Pulmonary sclerosis.
   7. Compression of the pulmonalis by an aortic aneurysm (Costa, 19).

III. Pathological changes of the arterial walls
   1. Syphilis (Barth, 31; Garreton, 32; Plenge, 33; Neuburger, 34, and Storch, 28).
   2. Tuberculosis (only in the small vessels).
   3. Other infective processes (Wildhagen, 35; Sherman, 36; Hoeldmoser, 37, and Therplan, 38).
   4. Organic changes of old age (Storch, 28, and Käpeli, 8).
   5. Traumas (Balaban, 12).

IV. Retractions from scars.

One such interesting case is published in the fourth edition of Groedel's "Atlas der Röntgen Diagnostik," illustration 359, Munich, 1924.

When we come to consider the clinical symptoms of pulmonary aneurysm we are again impressed by the lack of data in the literature. The symptoms, like those of aortic aneurysm, seem to be in one case very distinct, in another perhaps altogether lacking. We find mentioned most frequently bulging of the second and third left cartilage of the ribs, pulsation in the second left intercostal space, and systolic vibration.

At the same time, the lack of certain symptoms characteristic of an aneurysm of the aorta may be called very typical for the aneurysm of the pulmonary aorta, such as pulse differences, etc. But most important are the x-ray findings. In discussing the differential diagnosis, they may lead to

the final decision, but they do not always do so.

In regard to the differential diagnosis, we must consider the following conditions:

1. Tumors in the left hilus region, especially benign types, such as echinococcus and dermoid cysts, but also slowly growing malignant tumors.
2. Congested hilus, for instance, in siderosis, in severe chronic bronchitis and, first of all, in congestion of the pulmonary circulatory system.
3. Patent ductus Botalli and other congenital malformations.
4. Distortion of the artery through pleurisy and other pulmonary scars.
5. Primary pulmonary sclerosis.
6. Perforation of an aortic aneurysm into the pulmonary artery.
7. Aneurysms of the inner arch of the ascending aorta (especially important and difficult to recognize).

The case of Mr. C. will show how difficult it is, if not often impossible, to come to a conclusion about these questions of differential diagnosis.

The patient, a plantation owner, 42 years old, lives in South America at an altitude of 2,600 meters. His mother died at the age of 45 of an intestinal disease; his father enjoyed especially good health and died in his sixty-sixth year, of pneumonia. Both grandfathers died in their seventies, from carcinoma; one brother died of carcinoma of the rectum at the age of 43; one brother and two sisters are healthy. The patient did not drink much and smoked an average of thirty cigarettes a day. There was no history of syphilis. Wassermann reaction and lumbar puncture were always negative. He had always been healthy until about 1930, when he was examined in Paris because of indigestion (vomiting spells). Not until May, 1935, was this indigestion found to be caused by gallstones.

On the same occasion (1930), when the stomach was examined by the x-ray, a peculiar shadow was observed above the

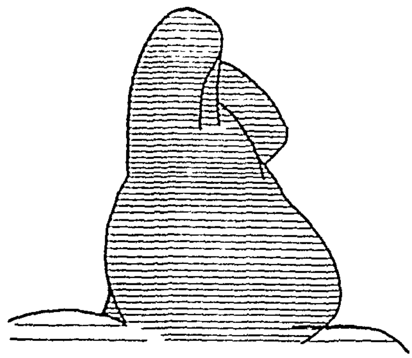


Fig. 1.

heart. According to the copy of a film made at that time (Fig. 1), a sharply outlined, curved shadow was seen in the region of the pulmonary arch of the left border of the heart. This shadow extended beyond the heart shadow by about two or three centimeters, running parallel to the pulmonary arch. Could we not have seen the pulmonary arch itself, we would have guessed that this shadow was the dilated pulmonary arch. A bismuth treatment was prescribed. After the treatment, the physician told the patient that the shadow had disappeared. But in a film made in 1931, we find the same shadow again, and this time it extends beyond the pulmonary arch by about four to six centimeters. The diagnosis of aneurysm of a syphilitic origin was again made and further bismuth treatment recommended.

When the gallstones were found, in May, 1935, and an operation considered necessary, the heart was re-examined. This time the diagnosis of a lung tumor was made. On four consecutive days heavy x-ray treatment was given, but, because the shadow had not changed in size after four weeks, a chest operation was recommended. Only one day before the date of the operation, another chest examination was made and, because the strange shadow pulsated slightly, the operation was cancelled. A mercury inunction treatment was recommended instead.

When I saw the patient for the first time, in 1935, he had no subjective symptoms whatever, except for a sensation of slight pulsation in the region of the second and third cartilages of the ribs, during moments of great excitement. A very careful and repeated clinical examination of the patient revealed absolutely negative findings in every respect; especially blood pressure, heart sounds, and electrocardiogram showed no alteration.

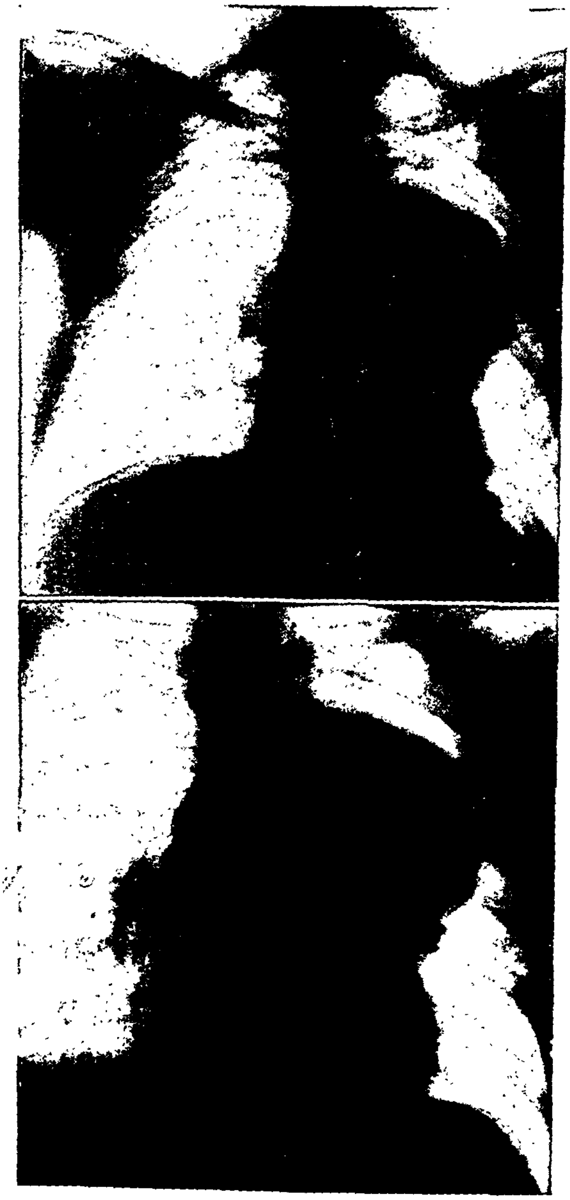


Fig. 2 (*upper left*).
Fig. 4 (*lower left*).

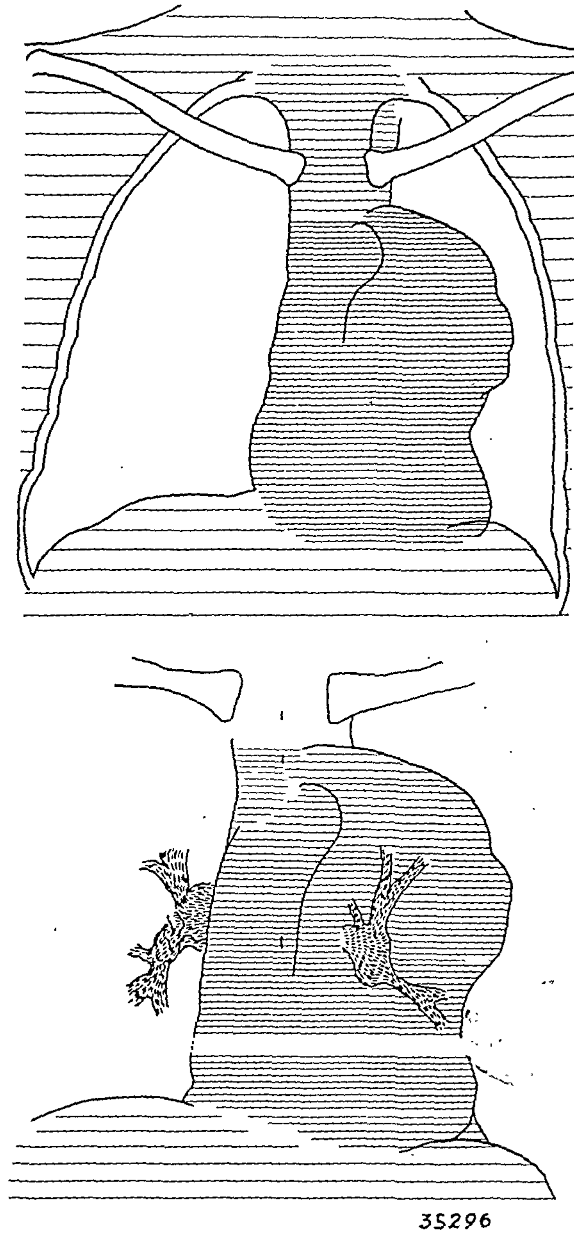


Fig. 3 (*upper right*).
Fig. 5 (*lower right*).

But the x-ray examination of the chest organs showed a distinctly changed film, compared with 1930 and 1931.

Figure 2 is a dorsoventral sagittal film and, like all the others, taken at 180 cm. focus-plate distance, $^1/_{20}$ second exposure time, 200 milliamperes, and averaging 75 kilovolts. This film shows well-expanded lungs, correctly situated left and right diaphragm, and slightly increased hilus shadow. On the right side of the vertebral

column, the heart shadow is hardly distinguishable; in other words, the heart is slightly displaced to the left side. The left lower arch of the heart shadow, corresponding to the left ventricle, shows only slightly increased measurements, and seems to be flattened. Above this lowest left arch of the heart shadow, we see a round shadow coming out of the heart shadow, covering the middle part of the left lung, sharply outlined against the lung, and two slight indentations showing. No details of the heart shadow, covered by this large shadow, can be distinguished; only the arch of the aorta and the ascending aorta can be seen distinctly. The ascending aorta and the arch are of normal size, perhaps even a little subnormal for the patient's age. But the big shadow is not altogether homogeneous; in the middle of it we see a large shadow shaped somewhat like a butterfly. These details can be seen in Figure 3 (a drawing from Figure 2).

In order to show up the details of the heart shadow more clearly, we used another technic; we put the patient 40 centimeters away from the plate so that the entire shadow became enlarged on the plate. The results are seen in Figure 4. Here, too, we recognize the different facts, namely, that the right border of the heart shadow scarcely exceeds the right border of the vertebral column, that the left ventricle cannot be much larger than normal; we distinguish here more clearly the shadow of the ascending aorta through the tumor shadow, and we may now decide that the butterfly-shaped shadow in the center of the tumor shadow corresponds exactly (in regard to distance from the middle line, configuration, etc.) to the left hilus shadow. All these facts are shown in Figure 5, which is a drawing made from Figure 4.

If we make a ventrodorsal sagittal film (Fig. 6), we obtain exactly the same details as just mentioned, but the tumor shadow appears a little larger, which indicates that the tumor must be nearer to the anterior chest wall than to the back.

So far, the following factors are apparent: the ascending aorta appears perfectly normal, the left ventricle does not seem to be much larger than normal; the right ventricle and the pulmonary artery cannot be

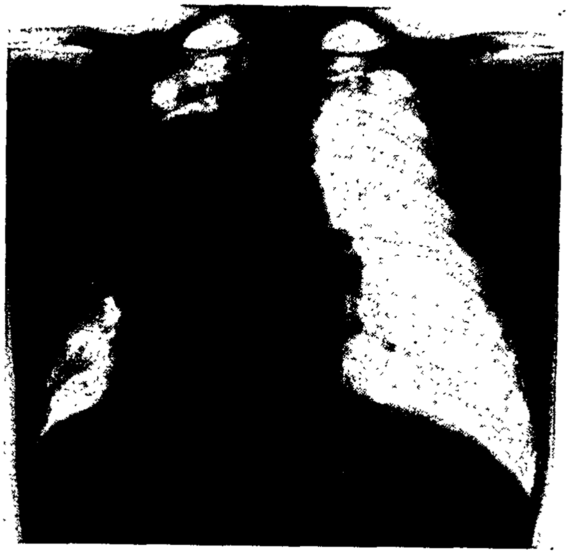
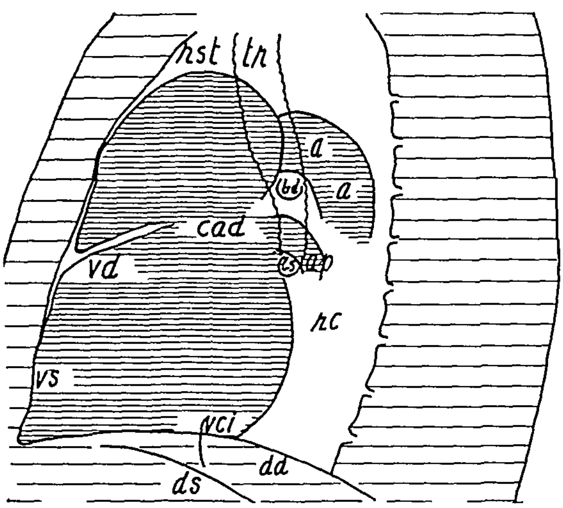


Fig. 6.

seen in these films; the tumor has about the same absorption quality as the heart; the tumor throws a homogeneous shadow through which the details of the lung can be distinguished; the tumor must be situated nearer the anterior chest wall than it is to the back.

Of greatest importance is the dextrosinistral lateral exposure of the chest which is shown in Figure 7, and in Figure 8, a drawing made according to this film. For comparison, I add, in Figure 9, the drawing of a lateral exposure of a normal person. In this and in the figures, the letters have the following meaning:

tr, trachea.
b s, left main bronchial tube.
b d, right main bronchial tube.
a, aorta.
r st, retrosternal space.
r c, retrocardial space.
p s, left lung.
p d, right lung.
d s, left diaphragm.
d d, right diaphragm.
v s, left ventricle.
v d, right ventricle.
a s, left auricle.



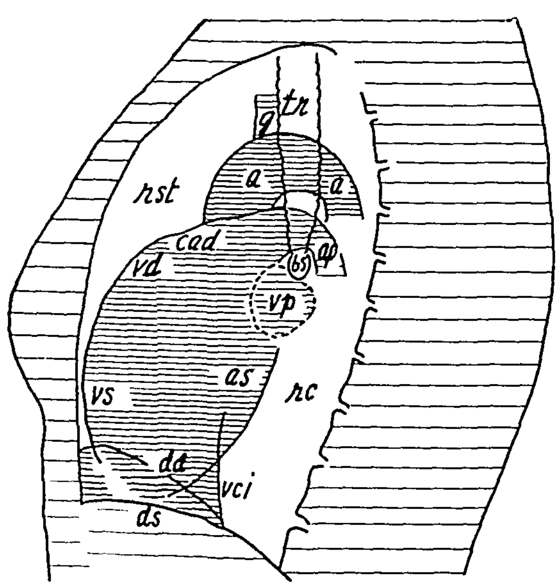


Fig. 7 (*upper*). Fig. 8 (*center*). Fig. 9 (*lower*).

a d, right auricle.
c a d, conus arteriosus dexter.
a p, arteria pulmonalis.
v p, vena pulmonalis.
g, great vessels.
v c i, vena cava inferior.

Studying the lateral x-ray film of our patient, the following facts are revealed: The lungs are normal in this direction, too, as well as both parts of the diaphragm. The heart shadow is distinctly dilated in its depth, being displaced somewhat downward but, at the same time, the shadow is markedly enlarged upward, filling up the retrosternal space more than is normal, which distinctly indicates an increased volume of the right ventricle. The heart shadow can be followed in the normal way up to the point of the conus arteriosus. The conus arteriosus and the shadow of the ascending aorta, which generally cross at this point under normal conditions, cannot be seen; instead of this, the heart shadow without interruption goes over into the tumor shadow, while the shadow of the right ventricle appears a few millimeters below the limits of the shadow. The borderlines of the shadow are sharp. They follow first the shadow of the sternum, they then make a big curve crossing the shadow of the trachea, coming back to the point of the conus arteriosus. The shadow of the tumor, as a whole, grows out of the heart shadow like a mushroom, with its stem attached in the region of the conus arteriosus.

Further, the lateral film shows distinctly, and unaltered, the shadow of the left arteria pulmonalis of the arch and the beginning of the descending aorta.

In addition to this film, Figure 10 demonstrates that the course of the esophagus, which is filled with opaque material, is entirely unaltered. Details can be seen in Figure 11, which shows the drawing made from Figure 10.

The important facts to be concluded from the lateral films are: the tumor shadow is connected with the heart shadow in the region of the conus arteriosus, the back of the arch and the descending aorta

have no connection with the tumor shadow; the divisions of the pulmonary arteries appear perfectly normal; the trachea and esophagus are not displaced and remain unaltered in their forms.

Fig. 10.

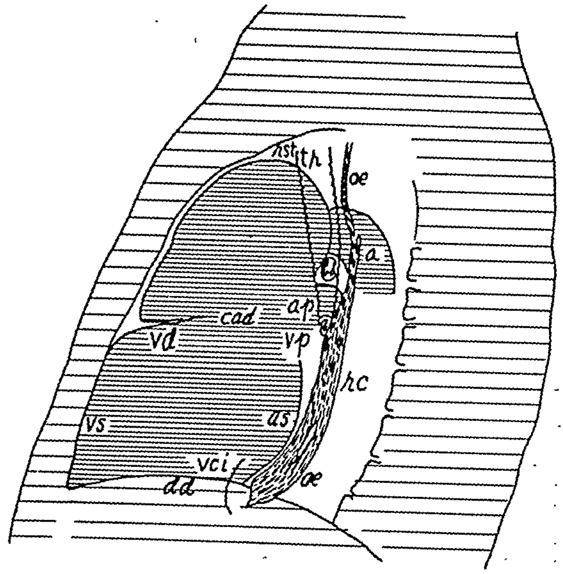


Fig. 11.

Compared with the findings of the films taken in the sagittal and lateral positions, those we obtain from the films taken in the oblique diameters are of minor importance. Figure 12 is the film taken in the dorsoventral first oblique diameter. Figure 13 is an exact drawing of Figure 12, and Figure 14 is the drawing of the film of a normal person, taken in this position.

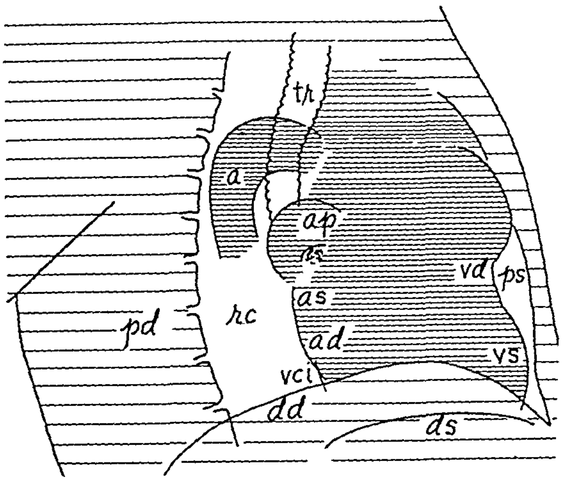
We find again that the tumor shadow is situated directly over the right ventricle, that there is no connection with the arch of the descending aorta or with the main branches of the pulmonary artery, and that there is no displacement or even connection with the trachea.

Figure 15 is taken in the ventrodorsal first oblique diameter. The details, which show the same facts but not as distinctly as in the dorsoventral diameter, can be seen in Figure 16, a drawing of the film. For comparison, I add the drawing of the film of a normal person (Fig. 17).

More interesting is Figure 18, which shows the heart in the second dorsoventral oblique diameter. If we compare the drawing of this film, as shown in Figure 19, with the drawing of a healthy man (Fig. 20), we will recognize the following facts: the tumor is situated above the heart shadow close to the right ventricle on the front side, and close to the right auricle at the back, covering the trachea and the two main bronchial tubes, which can be recognized through the tumor shadow. The main branch of the arteria pulmonalis and the descending aorta are not connected with the tumor.

In mirror-like reversal, we find the same details in Figure 21, which is made in the second ventrodorsal oblique diameter. Details will be recognized in Figure 22, the exact drawing of the film. Figure 23, the drawing of a normal individual, is shown for comparison.

As I mentioned before, the films taken in the oblique diameter cannot add anything of importance to the facts which were learned from the films taken in the lateral and sagittal positions, but they will show that the tumor is connected with the upper part of the right ventricle, changing its position in the same way as the right ventricle does when we revolve the body on its axis. Further, we discover also, by exami-



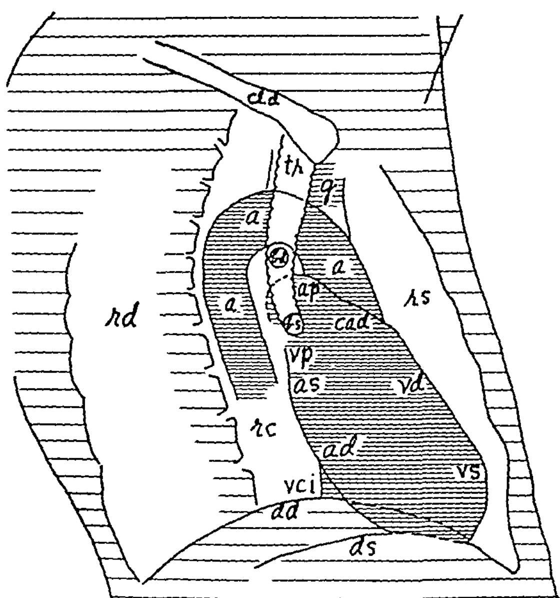
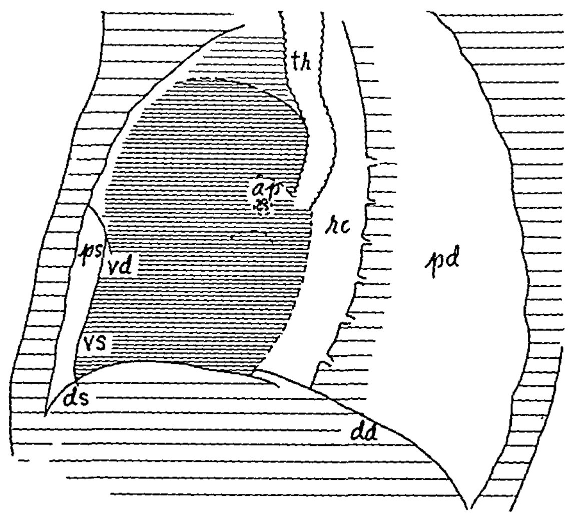


Fig. 12 (*upper*). Fig. 13 (*center*). Fig. 14 (*lower*).



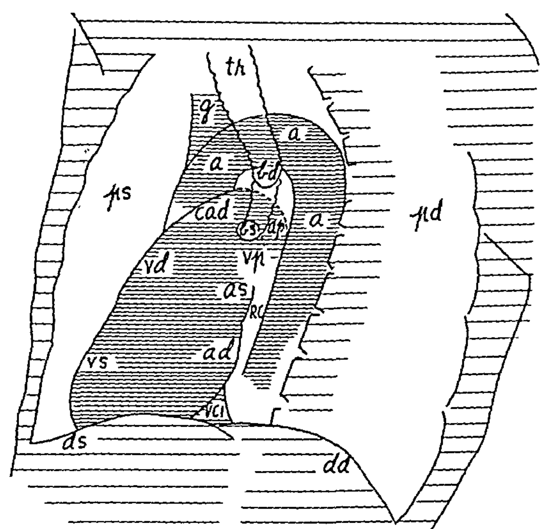
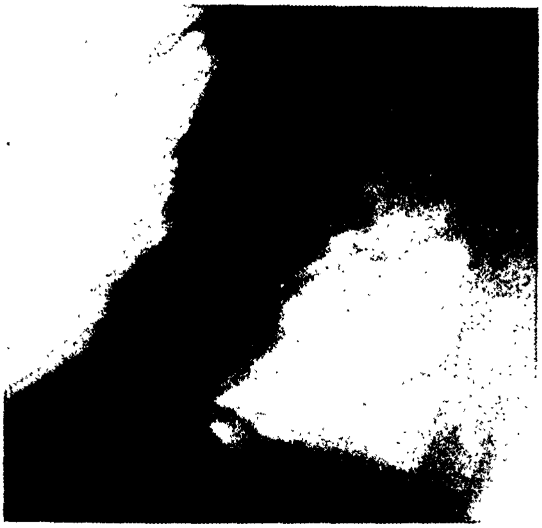
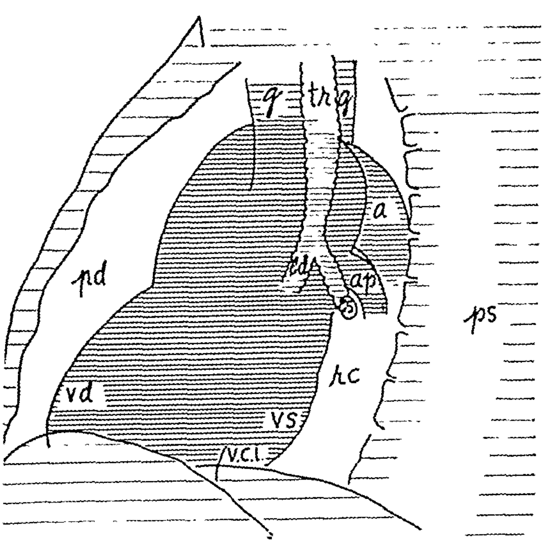


Fig. 15 (*upper*). Fig. 16 (*center*). Fig. 17 (*lower*).





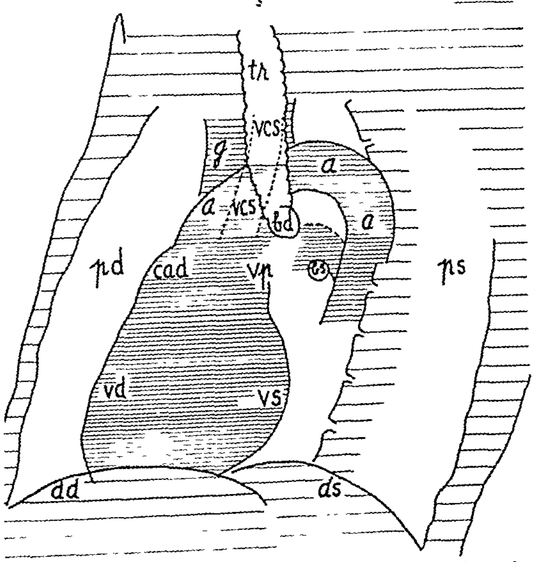
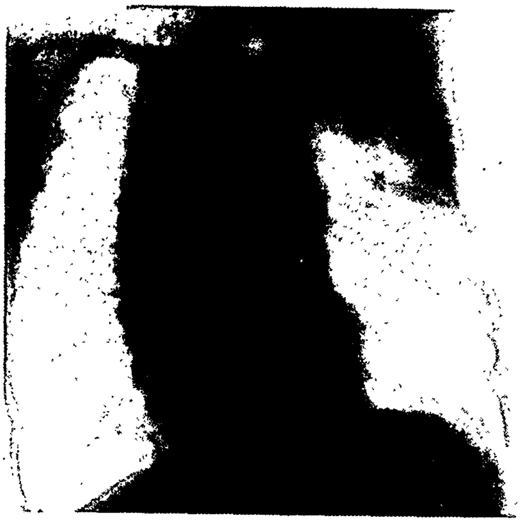
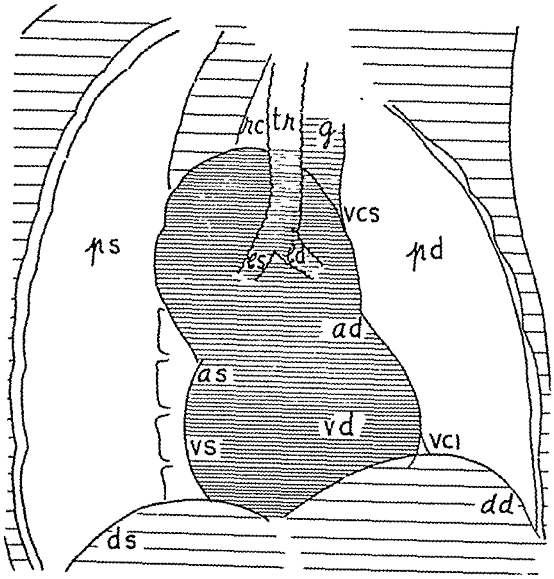


Fig. 18 (*upper*). Fig. 19 (*center*). Fig. 20 (*lower*).





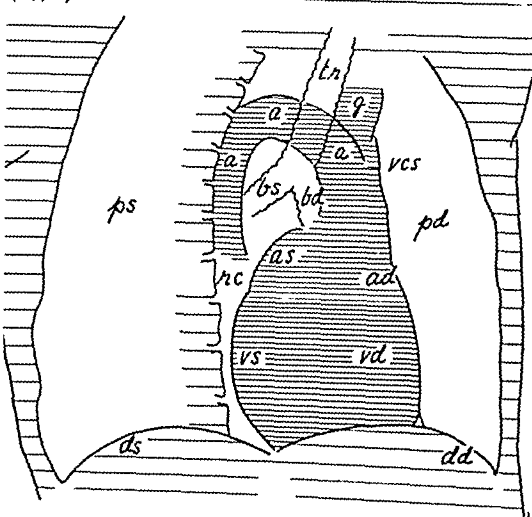


Fig. 21 (*upper*). Fig. 22 (*center*). Fig. 23 (*lower*).

nation in these diameters, that we find no connection of the tumor with any other part of the heart, or of the large vessels, or with any other thoracic organ, or its parts.

Fig. 24.

I believe that the situation will appear even more clear in Figure 24, in which the lateral exposure is taken at 40-centimeter distance between the body and the plate.

I think there can be no doubt that the tumor is connected with the heart, and that this connection is in the region of the upper part of the right ventricle, either at a point below the pulmonary valves (conus arteriosus) or above the pulmonary valves (pulmonary artery). A connection with the ascending aorta, especially with its inner arch, may be excluded by the sagittal films; a connection with the arch of the aorta or with the descending aorta may be excluded by the lateral films, and a connection with the main divisions of the pulmonary artery or any other part of the heart or of the other thoracic organs is excluded by all of the films.

We have so far excluded any kind of formation outside the heart, and we may take it for granted that the tumor is connected with the circulatory system. We excluded a connection with the aorta ascendens, especially its inner arch, with the arcus and descending aorta. We ascertained that the tumor is connected either with the conus arteriosus or the stem of the pulmonary artery.

What can be the nature of the tumor? There are only three possibilities: (1) heart aneurysm (conus arteriosus); (2) tumor of the heart; (3) aneurysm of the stem of the pulmonary artery.

An aneurysm of the heart cannot be absolutely excluded. But it is hardly believable that a heart aneurysm could ever assume such proportions without having ruptured long before. At least its pulsations should be violent.

A tumor of the heart should have shown some reaction to the x-ray treatment, because a heart tumor is generally of the radiosensitive type. Further, a tumor should show a "riding" pulsation; in other words, a tumor pulsates in just the same way as the part of the heart to which it is connected.

An aneurysm of the stem of the pulmonary artery should show an alternating pulsation with the right or left ventricle, because the aneurysm fills up just like the main vessels leaving the heart, while the systolic contraction of the heart takes place.

What did the roentgen kymographic plates show? Since I did not have my apparatus available, I asked Dr. I. Seth Hirsch and Mr. Schwarzschild to take the kymograms of my patient (Mr. C.). The result found was: the pulsations of the heart are of normal quality, the pulsation of the tumor is extremely weak. But, in spite of the tumor's weak pulsation, we can distinctly prove that the pulsation of the tumor alternates completely and constantly with the pulsation of the left ventricle and the right lower arch of the heart shadow which, of course, shows the transmitted pulsation of the right ventricle (Figs. 25 and 26). Hence there is no doubt that the shadow which is distinctly connected with the upper end of the right ven-

tricle is not caused by a heart tumor, nor by a heart aneurysm, but by an aneurysm of the stem of the pulmonary artery.

After three years' interval, the patient returned to my office. He told me that he first continued the bismuth treatment and remained in the high altitude, but then started to feel his heart. He suffered from shortness of breath and coughed considerably, especially at night or when lying

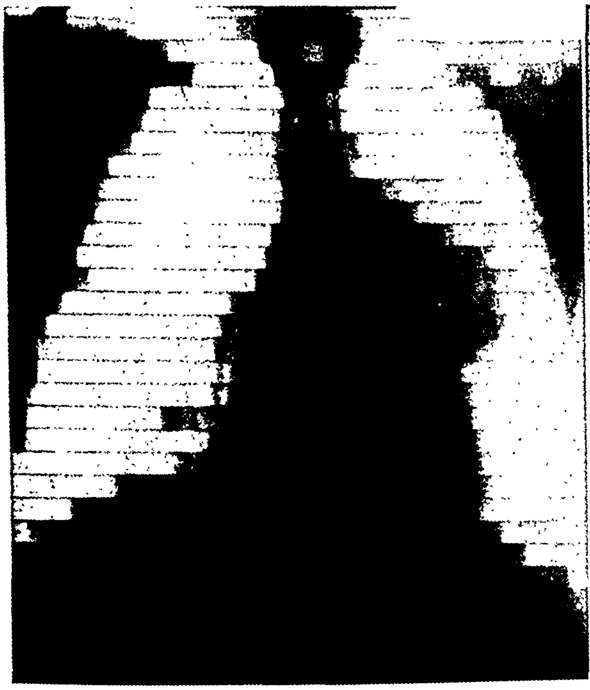


Fig. 25.

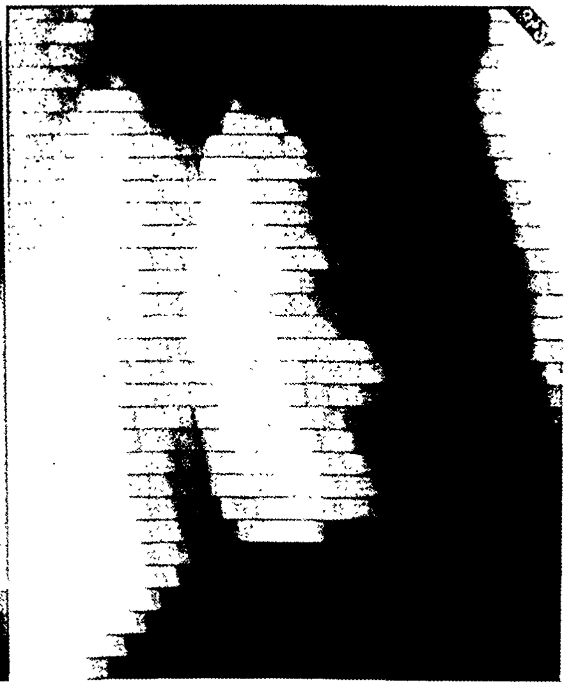


Fig. 26.

Fig 27.

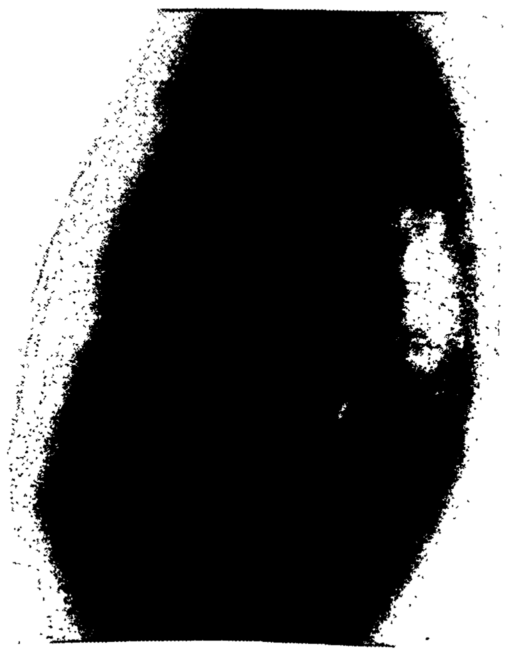


Fig 28.

down. He therefore went to a place of lower altitude (only 1,500 meters), but his condition grew worse. His stomach became upset, he started to vomit frequently, and for the past eight months he had stopped working. He also suffered from sciatica in his right leg. The right leg had been cooler for some time than the left leg.

Examination revealed his blood pressure to be 150/90 on both arms, the blood pressure at the legs measured 20 points higher on the right than on the left, but the oscillations were perfectly normal. The heart sounds were somewhat distant. The electrocardiogram showed perfectly normal tracings, except for low voltage of the R-waves and a flattened T in the routine extremity leads; but normal R-waves of the isolated left (CR_5) and right (CR_2) electrocardiograms of the chest leads. Here, too, the T-waves were flat. The urine and blood examinations showed no special abnormalities. The x-ray examination (Fig. 27) revealed that the tumor shadow growing out of the heart had increased enormously, filling up almost the entire left lung-field, pushing the heart somewhat to the right side. The lateral x-ray film (Fig. 28) also showed an increase of the shadow growing out of the heart, filling up the total retrosternal and retrocardiac space. The left diaphragm now stands much higher than the right. Examination before the fluoroscope showed scarcely any movement of the left diaphragm. No doubt the tumor is now producing a left-sided bronchial stenosis.

Examination of the gastro-intestinal tract revealed the liver pushing the contents of the abdomen to the left side, as a consequence of the low-standing right diaphragm, and, as a result of the high-standing left diaphragm, the stomach and part of the intestines are dislocated upward. There is no other pathological indication except two good-sized gallstones.

Referring to the literature and comparing our case with the descriptions of others, we believe that while in other cases the x-ray films could not be studied carefully, in our case the x-ray symptoms are so distinct we can hardly doubt the stated diagnosis. So it does not mean anything when we do not find the systolic murmur—which was found in other cases—if we do not find a marked pulsation, and other symptoms on the exterior of the thorax. We may explain these facts as favorable, showing that the aneurysm is highly organized, that it is filled with coagula, and, therefore, the blood content of the aneurysm changes very little, conforming to the action of the heart. On the other hand, the patient's youth—when the tumor was first detected—speaks against an aortic aneurysm and against a tumor, but for a pulmonary aneurysm.

But how can we explain the genesis of the aneurysm in our case? Arteriosclerosis may be excluded, not so much by the patient's age when the disease started, as by the clinical findings. Syphilis should have been excluded long ago according to the findings. If the serological findings were negative, they should, at least, have become positive after the first specific treatment. And the examination of the lumbar fluid was negative, too. Congenital syphilis also may be excluded, especially since the patient's liver was perfectly normal all the time.

I told the patient that he must have had an accident. Only then did he tell me that in his fourteenth year he had fallen from a wall two meters high, landing on his back so that he could not catch his breath for several minutes, but he did not feel any bad results. Ten years later he had an accident while horseback riding, fracturing a right rib.

I think we have the right to take the accident in the patient's fourteenth year, or both his accidents, as one of the causes for the later development of the aneurysm. But there is no reason why we should not, in this case, too, think that there was a second cause and this may have been a hypoplasia of the vessel walls, as described by B. S. Oppenheim. I think that we are justified for this assumption because the patient's aorta appears decidedly small for his age.

There is only one case of traumatic aneurysm of the pulmonary artery reported in the literature, namely, by Balaban and Pokidoff (12). But investigating the report, I must say that the films shown herein do not show anything except a somewhat prominent pulmonary arch of the heart shadow as we find it in asthenic patients or in harmless minor malformations of the heart. The clinical data and the patient's history, too, fail to prove the diagnosis in any way.

Therefore, I believe that our case is the first ever to be detected of a traumatic aneurysm of the stem of the pulmonary artery.

SUMMARY

The case history of a 45-year-old man is given. In his thirty-seventh year, a shadow was detected in the x-ray examination, about three centimeters in size, located in the area of the pulmonary artery. In spite of the fact that the patient had never had syphilis, that the Wassermann test and spinal fluid puncture were both negative, antisyphilitic treatment was instituted. The patient never showed any symptoms of arteriosclerosis, of any kind of infection, etc. Five years after the shadow was detected for the first time, the patient went to a medical institute, where a diagnosis of malignant tumor of the lungs was made. However, x-ray treatment was not successful. A chest operation was arranged for, but cancelled at the last moment because a very slight pulsation of the tumor was observed before the fluoroscope. At this time the tumor was from 8 to 10 cm. in size. By very careful x-ray examination in all diameters, the different diagnoses which could have been considered in such a case could be ruled out and, finally, the diagnosis of pulmonary aneurysm located at the stem of the pulmonary artery was settled upon. And again, by elimination, the conclusion was reached that this aneurysm must have been caused by an accident, perhaps on the basis of a hypoplastic wall. Only then did the patient reveal that he had had two severe accidents in his life, either of which was sufficient to have caused the aneurysm.

The patient was warned not to remain any longer at an altitude as high as 2,500 meters, but he disregarded this advice, and when he was seen three years later the aneurysm had grown enormously, filling out the entire left lung-field in the frontal x-ray film, and the entire retrosternal and most of the retrocardial space in the lateral view.

In the meantime, a stenosis of the left main bronchus with an immobilization of the left diaphragm had also taken place. Since during these eight years' observation, the heart never showed symptoms of decompensation, and since the tumor shadow in the x-ray film never showed a higher degree of pulsation, we can assume that this is a case of highly organized aneurysm.

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ROENTGEN DIAGNOSIS OF ABDOMINAL EFFUSIONS[1]

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THE use of the x-ray continues to broaden as roentgenologists in their investigations attempt to apply the use of this means of diagnosis to more and varied conditions. The early use of roentgenology was limited to the bones, since the contrast was so marked that it produced a differentiation on the x-ray film regardless of the poor technical qualities and unsatisfactory equipment at hand at that time. No diagnosis was made in abdominal conditions because of the lack of differentiation of opacity of the various intra-abdominal structures. Consequently, the use of opaque mixture became necessary and barium was used for examination of the gastro-intestinal tract. The next advance was an attempt to diagnose obstruction of the alimentary tract by means of the contrasting gas against the more dense surrounding structures. The last procedure has been the attempt to diagnose collections of intra-abdominal fluid and it is the purpose of this presentation to offer an analysis of the diagnostic features utilized toward this end.

Technic.—The roentgenographic examination in itself is very simple; it need not tire the patient. It can be carried out without much loss of time while the operating room is being made ready, in the event that operation is found to be necessary. A view in supine position usually is sufficient. An upright dorso-ventral or a lateral view of the abdomen in supine position may be added. Sometimes a small amount of barium may be administered orally or a barium enema may be given if the condition of the patient permits. Since the demonstration of the abdominal walls is desirable, it may be attained by the interposition of a wedge of aluminum or paraffin equivalent to 3 mm. Al. If such a wedge is not obtainable, the light of a floor lamp from 60 to 100 watts will suffice to transilluminate the usually over-exposed area of the abdominal flanks during routine exposure.

Anatomy.—Unlike the chest which harbors two contrastingly different radiotranslucent groups of organs, *i.e.*, the respiratory (lungs) and circulatory (heart and vessels), this is not the case in the study of the abdomen. The variety of densities here encountered is similar, ranging from 1.018 to 1.050 specific gravity, thus taxing the attention of the roentgenologist to a great degree. With the advance of the technic, *i.e.*, the Bucky diaphragm, and high-powered tubes, permitting shorter and more satisfactory exposures, the domain of the abdominal examination has been given great importance. Although stress is laid upon the valuable information derived from the flat plate of the abdomen, such as an obstruction, the manifestations of the peritoneum have remained quite obscure.

The present report contains more than 200 cases of radiographically reported effusions, 80 of which were proved by paracentesis, laparotomy, or autopsy. The radiographic examinations represent diffusely uniform densities throughout the abdomen and obliteration of the organ outlines of the spleen, liver, and sometimes kidneys. The density is comparable to a uniform sheet which is contrasted only with the gas-bearing loops of the intestines. In spite of this uniform density of the abdomen, these gas-filled loops present no deformity in their shape or outline as should be expected in the presence of solid masses. These loops seem to float.

[1]This is one of a series of papers contributed by friends and former pupils of I. Seth Hirsch, M.D.

Fig. 1. (Group 1. Large effusions.) Patient, A. M., 59 years of age. Paracentesis done and 192 oz. fluid removed.

A survey of the literature led us to the extensive work of Laurel and an attempt will be made to classify our material in conformity with the additional signs indicating the presence of fluid as laid down by him.

The pelvic cavity, paracolic and subphrenic spaces, being the most dependent parts of the abdomen, offer the most favorable sites for effusion.

Small and Moderate Amounts of Effusion.—Small and moderate amounts of fluid form homogeneous strips of the same density as the muscles and blend with these and such organs as the liver and spleen. These strips are separated from the walls of the abdomen by the subperitoneal fat layers which soon also become edematous and attain the density of the muscles and organs. These strips of exudate present a smooth side outwardly and extend between the air-filled loops, forming biconcave protrusions not unlike the teeth of a comb. These strips may be formed by exudate as well as by fibrinous collections. Strips of exudate may also extend between the

Fig. 2.

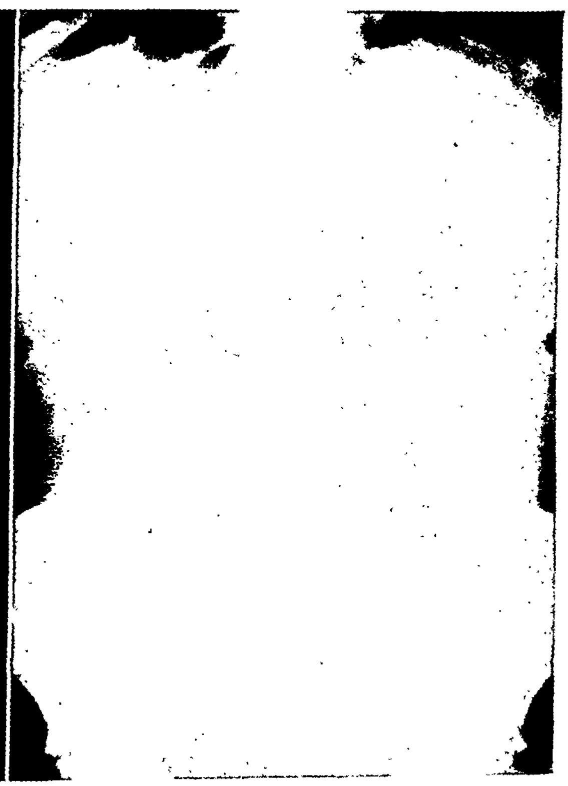

Fig. 3.

Fig. 2. (Group 1. Large effusions.) Patient, I. R., aged 48 years. Paracentesis revealed free fluid in abdominal cavity.

Fig. 3. (Group 1. Large effusions.) Patient, I. L. Exudate composed of serum and leukocytes and occasional plasma cells (600 c c.).

Fig. 4. (Group 2. Moderate effusions.) Autopsy revealed a subphrenic abscess on the right side coming from a fistulous tract caused by pyonephrosis of the left kidney, subacute peritonitis, and displacement without distortion.

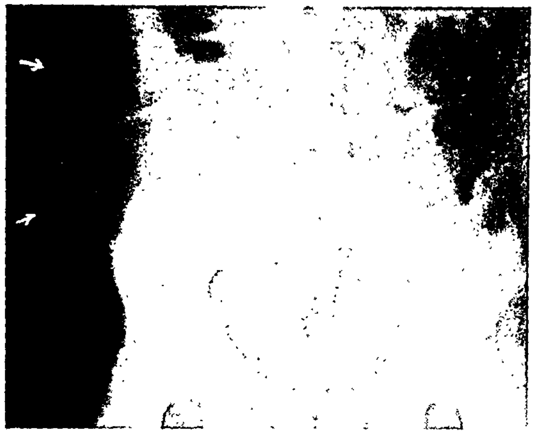

Fig. 5. (Group 2. Moderate effusions.) Postoperative findings revealed a retrocecal abscess, with foul-smelling pus, due to a ruptured appendix, and a large mass of intestines adherent to the parietal peritoneum.

haustra. Here, one must watch for plicæ epiploicæ or cross-section of haustra. Since similar strips are also formed by fibrinous deposits, the differentiation can be made only by change of the position during examination during which the fluid will change its shape. Adjoining walls of inflamed gut in peritonitis may resemble these manifestations and must not be confused.

Encysted Effusions.—Beside these appearances of exudate, one may encounter uniform round or angular densities which may be caused by fluid collections which, in turn, may be caused by fluid within a loop or by an omental mass or by an encysted empyema. The differentiation is difficult and may require additional views and examinations. Omental masses are frequently found in the left upper quadrant, at times displacing the stomach, or below the transverse colon. In the latter location they are not sufficiently dense to indicate fluid. Encysted effusions are fairly large homogeneous shadows in various parts of the abdomen in addition to those caused by the spleen and urinary bladder. But, here, one may also encounter empty or fluid-bearing small intestines giving homogeneous shadows closely resembling those of an exudate when they are surrounded by gas-filled small or large intestinal coils. These encysted collections may sometimes contain gas, be manifold, and intercommunicate. Thus, because they do not remain under pressure they cannot be palpated and, therefore, their evidence can be discovered only by x-ray examination. Fixed intestinal loops may become displaced by these fluid collections without any change in their shape. They may also be affected by the process and may present enlargement and irregular mucosal patterns and spasms after administration of a contrast enema. The subperitoneal fatty layers also suffer from the extension of the exudate by the edema and the engorgement of their vessels, assuming the density of the adjoining muscle. In this event, one must guard against amyloidosis, cachexia, senility, and infancy because the first three conditions cause disappearance of the fatty layers while in the last such layers are not yet developed.

Fig. 6.

Fig. 7.

Fig. 6. (Group 3. Minimal effusions.) Patient, J. N. Small intestinal obstruction ten days after appendectomy. Peritonitis and free pus.

Fig. 7. (Group 3. Minimal effusions.) Patient, E. B., 28 years of age. Operation revealed a large quantity of pus in the abdomen.

The iliopsoas spaces may obliterate when the inflammation has spread to the retroperitoneal tissues and a distinct reproduction of the vessels in the subcutaneous fatty layer takes place (Laurel). Respiration is difficult since the fluid presses against the diaphragmatic domes, flattening them out and elevating them upward and posteriorly. Thus, atelectasis may ensue and unilateral or bilateral pleural effusions take place.

CONCLUSIONS

Roentgen signs of abdominal effusions in which large and moderate amounts of fluid, including the encysted effusions, are found, are:

1. Uniformly increased density throughout the entire abdomen with obliteration of the borders of the abdominal organs such as the liver, spleen, and kidneys.
2. Elevation and flattening of one or both diaphragms with or without effusion on one or both sides and decreased or absent respiratory excursions.
3. The gas-bearing loops of the intestine do not show any change in shape despite increased density.
4. Obliteration of the subperitoneal and intramuscular fat layers.
5. Engorgement of the vessels with their distinct reproduction in the subcutaneous fatty layer (Laurel).
6. No change in the shape of the gut despite the displacement by the encapsulated fluid and the jagged appearance of the mucosal pattern in case of extension of the process. Fluid levels in case of gas abscesses.
7. Peritoneal irritation after the administration of barium manifested by the contraction of the gut, also encountered in other conditions such as pyelonephritis.

Roentgen signs of minimal abdominal effusions are:

1. Preservation of the shape of the intestines at the site of the effusion.

2. Obliteration of the subperitoneal fat layer.

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ACTIONS PERTAINING TO RADIOLOGY AT THE ST. LOUIS SESSION OF THE A.M.A.

Among the several official pronouncements pertaining to radiology which emanated from the annual meeting of the American Medical Association in St. Louis last June, the most important were those issued by the Reference Committee on Medical Education and subsequently adopted by the House of Delegates.

A revision of Section 7 of the "Essentials of a Registered Hospital," recommended by the Council on Medical Education and Hospitals, approved by the Reference Committee, and adopted by the House of Delegates, will have a far-reaching effect upon the practice of radiology in hospitals in the future. Though no drastic or sudden change in hospital-radiologist relationships is contemplated, new requirements embodied in the "Essentials" will undoubtedly lead to a gradual solution of some current controversies.

The revision is significant and definite. It followed a series of conferences between the Council and the Inter-Society Committee during the past year. A thorough discussion of the present tendency for hospitals to secure a profit from the professional practice of radiologists practising within its purlieu convinced the members of the Council that a clearer definition of the proper relationship between radiologists and hospitals was desirable. Accordingly, the Council agreed last February to recommend certain revisions in the "Essentials of a Registered Hospital."

Included in the complete report of the Council, which was adopted by the House of Delegates at the June meeting, was the following (Jour. Am. Med. Assn., **112**, 2166, 2167, May 27, 1939):

Essentials of a Registered Hospital

General Statement.—Hospitals should be organized and conducted primarily for the purpose of providing facilities where the sick and the injured of the community may be given scientific and ethical medical care.

Registration is a basic distinction between all recognized hospitals and those that are refused recognition. It is a prerequisite to the consideration of a hospital for approval for interns or for residencies in specialties.

The registration of hospitals, the approval of hospitals for interns, approval for residencies in specialties, and all other service of the Association regarding hospitals is carried on by the Council on Medical Education and Hospitals. Separate essentials have been adopted for each of these types of approval.

It is the desire of the Council to co-operate in every way for the improvement of hospital service, whereby the sick and injured may be provided with scientific and ethical medical care.

The Council does not have nor does it assume legal authority over any hospital. It recognizes clearly that the officers in charge of such institutions have the unquestioned right to conduct the hospitals in any way they may deem wise. If a hospital desires to have its name appear on the American Medical Association Hospital Register and thus have the endorsement of that Association, it should be willing to comply with the principles which the Council on Medical Education and Hospitals considers necessary.

. . . .

V. *Radiology.*—1. The responsibility for all radiologic examinations must rest on the physician-roentgenologist who is head of the department. His findings and conclusions for all examinations should be placed in the patient's chart. Nothing in this provision should preclude additional study and interpretations by qualified attending physicians on the staff.

2. The physician-roentgenologist should be preferably one who is a diplomate of the American Board of Radiology or a physician whose qualifications are acceptable to the Council on Medical Education and Hospitals of the American Medical Association.

3. It shall not be the policy of the hospital to make a profit from the department of radiology.

Equally important to the future of radiology was the action of the Council on Medical Education and Hospitals in approving the "Manual of Desirable Standards for Hospital Radiological Departments" which was submitted in tentative form by the Inter-Society Committee and a committee of the American College of Radiology. These two groups had previously collaborated in preparing a manual of "desirable standards" with the hope of securing the Council's approval. First discussed with the Council during the College Conference last February, the proposed Manual was revised to conform with suggestions offered at that meeting. The final draft was resubmitted in St. Louis, where the Council adopted a motion expressing its accord with the principles contained therein.

When final authority is received from the American College of Radiology the Manual

will be printed and distributed to all members of national radiological societies and will be available upon request to radiologists, hospital administrators, and others. Members of the College committee responsible for this important project are L. H. Garland, M.D., V. W. Archer, M.D., and R. A. Arens, M.D.

Only one resolution was introduced by the Section on Radiology and its purpose was to express the gratitude of the Section to the A. M. A. headquarters staff for support and assistance rendered to representatives of organized radiology. The resolution was adopted by the House of Delegates as follows (Jour. Am. Med. Assn., **112**, 2169):

Resolutions Expressing Appreciation of Staff at Headquarters

Dr. E. H. Skinner, Section on Radiology, presented the following resolutions, which were referred to the Reference Committee on Medical Education:

WHEREAS, The medical profession of America has been confronted with vital issues affecting the welfare of all citizens and the free integrity of medicine and calling for courageous leadership and positive action by the organized profession, and

WHEREAS, This action and leadership has been maintained through a loyal and competent headquarter's staff, and

WHEREAS, The Council on Medical Education and Hospitals, the Bureau of Medical Economics and other departments in the headquarters office have helped materially in the efforts of radiologists to maintain and raise the standards of radiologic practice, through which efforts definite progress in the gradual solution of some of our vexing problems has been achieved, thereby protecting medicine against insidious harm to one of its parts; therefore be it

RESOLVED, That the Section on Radiology expresses its appreciation and commendation of the members of the headquarters staff for their cordial assistance to the Inter-Society Committee for Radiology, as representative of all radiologists, and to this section in upholding and applying accepted principles to assure the continued advancement of radiologic practice and the protection of the science against adverse influences; and be it further

RESOLVED, That a copy of these resolutions be spread on the minutes of this session of the House of Delegates.

Particular attention was given by radiologists to a resolution introduced by the Illinois delegation which found fault with the action of the Judicial Council last year when it declared that the rental of radium should be regulated by certain restrictions. This action of the Judicial Council (Jour. Am. Med. Assn., **110**, 1489, April 30, 1938, Rental of Radium) was as follows:

"A widespread practice of renting radium for the treatment of patients by physicians not owning, or being experienced in the use of, radium has caused considerable discussion during the past year. Ordinarily instructions in the technic of the use of radium are sent by the person furnishing it. Sometimes the radium is furnished by a commercial concern, sometimes by a physician owning it. The advisability of the use of such a powerful agency by those not trained in its use and the ethics involved of prescribing and directing its use by a person who has not examined or seen the person on whom it is to be used, has come before the Council. As a result of a rather extensive correspondence, both from those favoring its use as described and those opposed, the Judicial Council is of the opinion that the prescribing and directing of its use in the case of a patient whom the prescriber has not examined or seen is an *unethical medical procedure. The Council recognizes* that advice and help in difficult cases is often furnished by those in a position to be of possible, or probable, assistance, but it believes that the great dangers accompanying the use of radium remove that particular remedy from the field of advice without personal contact with the patient."

The resolution was presented through the Illinois delegation and originated from the Adams County Medical Society of Illinois in which the city of Quincy is located. Its adoption was urged before the Reference Committee by several physicians from Illinois, Wisconsin, and Indiana. It was opposed by many physicians and radiologists from coast to coast and the action of the Judicial Council was defended by the Chairman, Dr. George E. Follansbee. The resolution was as follows (Jour. Am. Med. Assn., **112**, 2176):

Resolution on Prescribing of Radium

Dr. E. S. Hamilton, Illinois, presented the following resolution, which was referred to the Reference Committee on Amendments to the Constitution and By-laws and to the Judicial Council:

The report of the Special Committee appointed by the President of the Adams County Medical Society (Ill.) to study the present ruling of the American Medical Association relative to the rental of radium is as follows:

WHEREAS, At the San Francisco session last year the House of Delegates of the American Medical Association passed certain resolutions condemning the rental of radium under certain conditions, namely, the prescribing and directing of the use of radium in the case of a patient whom the prescriber has not examined or seen; and

WHEREAS, In consideration of the fact that such a rigid ruling would work a great hardship on thousands of members of the American Medical Association and cause great suffering to thousands of citizens of the United States, especially those who are remotely situated from sources of radium; that many patients would be denied the use of radium, if they were compelled to make long trips to a source of radium; that many patients have such great confidence in their physicians that they distinctly prefer that he personally administer such radium treatment; that since the pioneers in radium therapy and probably the greatest advocates of radium were not radiologists but leading gynecologists and dermatologists; that since many specialists are

well qualified to make many of the applications of radium, because of their specialized knowledge and surgical technic, as is the average radiologist; that since an experience of over twenty-five years, during which time many thousands of patients have been treated, has shown that many conditions in which radium is commonly used can be satisfactorily treated and with great benefit to the patient by the average physician under proper supervision and without a radiologist personally examining the patient on whom the radium is to be used; that because of the great expense of radium it is not practical for the average physician to own it; that the average physician sees so few cases in which radium is needed in his practice that it is not practical for him to make the large financial outlay to purchase it, and that since it is already considered an ethical procedure for physicians to lease radium for long periods or to own it outright, regardless of their qualifications to use it; therefore be it

RESOLVED, That it is considered ethical for a member of the American Medical Association personally to describe or write a description of a patient on whom he wishes to consider the use of radium and submit it to an experienced radiologist who likewise is a member of the American Medical Association; that if the condition is one in which radium is frequently used and if the radiologist believes the physician submitting the description can use radium with benefit to the patient, he may, therefore, prepare suitable radium applicators, recommend a technic of application and suggest dosage for the treatment of the case under consideration.

A motion to adopt this resolution with the recommendation that a copy be sent to the Secretary of the Illinois State Medical Society, and that the delegate of the Adams County Medical Society be instructed to present it to the House of Delegates of the Illinois State Medical Society at its next annual session (Rockford) for their approval and with the request that the delegates of the Illinois State Medical Society be requested to present it to the House of Delegates of the American Medical Association at its St. Louis meeting was adopted without dissenting vote. The Committee on Resolutions recommended the approval of the resolution presented by the Adams County Medical Society and the concurrence in its recommendations.

Adopted by House of Delegates May 4, 1939, Illinois State Medical Society.

The action of the Reference Committee was as follows (Jour. Am. Med. Assn., **112**, 2294):

Report of Reference Committee on Amendments to Constitution and By-laws

Dr. Charles E. Mongan, Chairman, presented the following report:

. . . .

Resolution on Prescribing of Radium: After careful consideration of the subject matter of the resolution and the action of the House of Delegates of the American Medical Association in 1938 at which the recommendation of the Judicial Council was approved, your reference committee believes that a careful reading of the report of the Judicial Council, which was to the effect that a physician prescribing for a patient without examining the said patient is performing an unethical act, will show that there was nothing expressed in the opinion of the Judicial Council regarding the owning or leasing of radium other than the relationship of the lessor to the user of the radium.

Your reference committee would invite the careful attention of each member of the House of Delegates to the exact wording of the resolution adopted by the House of Delegates in the 1938 session.

Your reference committee reiterates the language of the report of the Reference Committee on Amendments to the Constitution and By-Laws in 1938, which read as follows: "After due consideration of the matter, your committee feels that the phraseology should remain. Any exceptions to the general principle involved would defeat its purpose."

Your reference committee recommends, therefore, that the resolution presented by the Illinois State Medical Society be not adopted.

Respectfully submitted: Charles E. Mongan, *Chairman;* Edgar A. Hines, T. K. Gruber, Felix P. Miller, E. G. Wood.

The House of Delegates ratified this report.

There is an apparent failure on the part of many physicians to understand the simple implications of this action by the Judicial Council. In a previous issue of the *Bulletin* there is a complete exposition of the import and practical application of the resolution (RADIOLOGY, **31**, 234–236, August, 1938). Briefly, it declares unethical the prescribing of radium by any physician who has not examined the case. It does not preclude the rental of a definite amount of radium in a particular applicator which has been ordered by the physician who has examined the given case and knows what he wants.

An interesting resolution was introduced by the Section upon Pathology which indicates that other than radiologists are concerned now with the relationship of hospitals and physicians. Possibly the pathologists have taken some courage from the successful issue of the seven-year progression of radiologic ambitions. It is apparent that other than the specialties so intimately identified with hospital practice are now aware of the implications when hospital administration attempts to provide medical services by contract. The resolution of the pathologists was as follows:

Resolution Limiting Directorship of Approved Clinical Laboratory to Licensed Physician

Dr. Frederic E. Sondern, New York, presented the following resolution, which was referred to the Reference Committee on Medical Education:

WHEREAS, Years ago the examinations made by clinical laboratories were largely factual in nature and, as a consequence, a portion of the work was done by chemists and technicians not having medical degrees or being licensed to practice medicine;

WHEREAS, Particularly in the last one or two decades, the developments in laboratory medicine have been such as to require clinical medical knowledge for

the safe performance of many of the newer diagnostic procedures undertaken; and

WHEREAS, Specimens are obtained by surgical means from the spinal canal, veins, and organs of the body, and drugs and dyes are injected for the purpose of various functional tests, all definitely requiring clinical medical experience and judgment for their performance and interpretation if the safety of the patient is to be guarded; therefore be it

RESOLVED, That only a licensed physician duly qualified as a clinical pathologist may serve as the director of an approved clinical laboratory, as such practice is a specialty of medicine.

The action upon this by the Reference Committee which was sustained by a vote of the House of Delegates, was as follows:

Report of Reference Committee on Medical Education

Dr. Harvey B. Stone, *Chairman*, presented the following resolution as a substitute for the Resolution Limiting Directorship of Approved Clinical Laboratory to Licensed Physician, which was adopted on motion of Dr. Stone, duly seconded and carried:

WHEREAS, Years ago the examinations made by clinical laboratories were largely factual in nature and, as a consequence, a portion of the work was done by chemists and technicians not having medical degrees or being licensed to practise medicine; and

WHEREAS, The developments in laboratory medicine, particularly in the last one or two decades, have been such as to require clinical medical knowledge for the safe performance of many of the newer diagnostic procedures undertaken; and

WHEREAS, Specimens are obtained by surgical means from the spinal canal, veins, and organs of the body, and dyes and other drugs are injected for the purpose of various functional tests, all definitely requiring clinical medical experience and judgment for their performance and interpretation if the safety of the patient is to be guarded; therefore, be it

RESOLVED, That the American Medical Association specifically recognizes the practice of clinical pathology as a specialty of medicine and believes that those persons who practise it and who act as directors of clinical laboratories must be graduates of recognized medical schools and licensed to practise medicine in their respective States; and further be it

RESOLVED, That owing to the nature of the subject, the American Medical Association recognizes that it is necessary for these persons to complete at least three years of adequate training in clinical pathology, in addition to the training which they have received in regular courses in medical schools, before assuming the directorship of clinical laboratories.

E. H. SKINNER, M.D.

RADIOLOGICAL SOCIETIES IN THE UNITED STATES

Editor's Note.—Will secretaries of societies please cooperate with the Editor by supplying him with information for this section? Please send such information to Leon J. Menville, M.D., 1201 Maison Blanche Bldg., New Orleans, La.

CALIFORNIA

California Medical Association, Section on Radiology.—Chairman, Karl M. Bonoff, M.D., 1930 Wilshire Blvd., Los Angeles; *Secretary,* Carl D. Benninghoven, M.D., 95 S. El Camino Real, San Mateo.

Los Angeles County Medical Association, Radiological Section.—President, E. N. Liljedahl, M.D., 1322 North Vermont Ave., Los Angeles; *Vice-president,* M. L. Pindell, M.D., 678 South Ferris Ave.; *Secretary,* Wilbur Bailey, M.D., 2007 Wilshire Blvd.; *Treasurer,* Henry Snure, M.D., 1414 South Hope Street. Meets every second Wednesday of each month at County Society Building.

Pacific Roentgen Club.—Chairman, Karl M. Bonoff, M.D., Los Angeles; *Members of Executive Committee,* I. S. Ingber, M.D., A. C. Siefert, M.D., D. R. MacColl, M.D.; *Secretary-Treasurer,* L. Henry Garland, M.D., 450 Sutter St., San Francisco. Executive Committee meets quarterly; Club meets annually during annual session of the California Medical Association.

San Francisco Radiological Society.—Secretary, L. H. Garland, M.D., 450 Sutter Street. Meets monthly on first Monday at 7:45 P.M., alternately at Toland Hall and Lane Hall.

COLORADO

Denver Radiological Club.—President, F. B. Stephenson, M.D., 452 Metropolitan Bldg.; *Vice-president,* K. D. A. Allen, M.D., 452 Metropolitan Bldg.; *Secretary,* E. A. Schmidt, M.D., 4200 E. Ninth Ave.; *Treasurer,* H. P. Brandenburg, M.D., 155 Metropolitan Bldg. Meets third Tuesday of each month at homes of members.

CONNECTICUT

Connecticut State Medical Society, Section on Radiology.—Chairman, Samuel M. Atkins, M.D., 63 Central Ave., Waterbury; *Secretary-Treasurer,* Max Climan, M.D., 242 Trumbull St., Hartford. Meetings twice annually in May and September.

DELAWARE

Affiliated with Philadelphia Roentgen Ray Society.

FLORIDA

Florida Radiological Society.—President, H. B. McEuen, M.D., Jacksonville; *Vice-president,* Joseph H. Lucinian, M.D., Miami; *Secretary-Treasurer,* John N. Moore, M.D., 210 Professional Bldg., Ocala. Meetings held in November and at the annual meeting of the Medical Association of Florida in the spring.

GEORGIA

Georgia Radiological Society.—President, James J. Clark, M.D., Doctors Bldg., Atlanta; *Vice-president,* L. P. Holmes, M.D., University Hospital, Augusta; *Secretary-Treasurer,* Robert C. Pendergrass, M.D., Prather Clinic, Americus. Meetings twice annually, in November and at the annual meeting of the Medical Association of Georgia in the spring.

ILLINOIS

Chicago Roentgen Society.—President, Roe J. Maier, M.D.; *Vice-president,* Adolph Hartung, M.D.; *Secretary,* Chester J. Challenger, M.D., 3117 Logan Blvd. Meetings the second Thursday of each month from October to May, except December, at the Hotel Sherman.

Illinois Radiological Society.—President, Cesare Gianturco, M.D., 602 W. University Ave., Urbana; *Vice-president,* Fred H. Decker, M.D., 802 Peoria Life Bldg., Peoria; *Secretary-Treasurer,* Edmund P. Halley, M.D., 968 Citizens Bldg., Decatur. Meetings quarterly by announcement.

Illinois State Medical Society, Section on Radiology.—The next meeting will be in Peoria, in May, 1940. The officers are: *Chairman,* Warren W. Furey, M.D., 6844 Oglesby Ave., Chicago; *Secretary,* Harry W. Ackemann, M.D., 321 W. State St., Rockford.

INDIANA

The Indiana Roentgen Society.—President, Juan Rodriguez, M.D., 2902 Fairfield Ave., Fort Wayne; *President-elect,* H. H. Inlow, M.D., Shelbyville; *Vice-president,* Wemple Dodds, M.D., Crawfordsville; *Secretary-Treasurer,* Clifford C. Taylor, M.D., 23 E. Ohio St., Indianapolis. Annual meeting in May.

IOWA

The Iowa X-ray Club.—Holds luncheon and business meeting during annual session of Iowa State Medical Society.

KENTUCKY

Kentucky Radiological Society.—President, D. B. Harding, M.D., Lexington; *Vice-president,* I. T. Fugate, M.D., Louisville; *Secretary-Treasurer,* Joseph C. Bell, M.D., 402 Heyburn Bldg., Louisville. Meeting annually in Louisville, third Sunday afternoon in April.

MAINE

See New England Roentgen Ray Society.

MARYLAND

Baltimore City Medical Society, Radiological Section.—Chairman, Whitmer B. Firor, M.D., 1100 N. Charles St.; *Secretary,* Walter L. Kilby, M.D., 101 W. Read St. Meetings third Tuesday of each month.

MASSACHUSETTS

See New England Roentgen Ray Society.

MICHIGAN

Detroit X-ray and Radium Society.—President, Sam W. Donaldson, M.D., 326 N. Ingalls St., Ann Arbor;

Vice-president, Clarence Hufford, M.D., 421 Michigan Ave., Toledo, Ohio; *Secretary-Treasurer*, E. R. Witwer, M.D., Harper Hospital, Detroit. Meetings first Thursday of each month from October to May, inclusive, at Wayne County Medical Society club rooms, 4421 Woodward Ave.

Michigan Association of Roentgenologists.—President, C. K. Hasley, M.D., 1429 David Whitney Bldg., Detroit; *Vice-president*, M. R. Cooley, M.D., Mercy Hospital, Jackson; *Secretary-Treasurer*, C. S. Davenport, M.D., 609 Carey St., Lansing. Meetings quarterly by announcement.

MINNESOTA

Minnesota Radiological Society.—President, Leo G. Rigler, M.D., University Hospital, Minneapolis; *Vice-president*, Harry M. Weber, M.D., Mayo Clinic, Rochester; *Secretary*, John P. Medelman, M.D., 572 Lowry Medical Arts Bldg., St. Paul. These officers will assume their duties after the Summer meeting which will be held in connection with the Minnesota State Medical Society, May 31 to June 2, 1939.

MISSOURI

The Kansas City Radiological Society.—President, L. G. Allen, M.D., 907 N. 7th St., Kansas City, Kansas; *Secretary*, Ira H. Lockwood, M.D., 306 E. 12th St., Kansas City, Mo. Meetings last Thursday of each month.

The St. Louis Society of Radiologists.—President, Paul C. Schnoebelen, M.D.; *Secretary*, W. K. Mueller, M.D., University Club Bldg. Meets on fourth Wednesday of October, January, March, and May, at a place designated by the president.

NEBRASKA

Nebraska Radiological Society.—President, T. T. Harris, M.D., Clarkson Memorial Hospital, Omaha; *Secretary*, D. Arnold Dowell, M.D., 117 S. 17th St., Omaha. Meetings first Wednesday of each month at 6 P.M. in Omaha or Lincoln.

NEW ENGLAND ROENTGEN RAY SOCIETY

(Maine, New Hampshire, Vermont, Massachusetts, and Rhode Island.) *President*, Langdon T. Thaxter, M.D., Maine General Hospital, Portland, Maine; *Secretary*, Aubrey O. Hampton, M.D., Massachusetts General Hospital, Boston. Meetings third Friday of each month from October to May, inclusive, usually at Boston Medical Library.

NEW HAMPSHIRE

See New England Roentgen Ray Society.

NEW JERSEY

Radiological Society of New Jersey.—President, P. S. Avery, M.D., Middlesex Hospital, New Brunswick; *Vice-president*, J. G. Boyes, M.D., 912 Prospect Ave., Plainfield; *Treasurer*, H. A. Vogel, M.D., 1060 E. Jersey St., Elizabeth; *Secretary*, W. James Marquis, M.D., 198 Clinton Ave., Newark; *Counsellor*, A. W. Pigott, M.D., Skillman. Meetings at Atlantic City at time of State Medical Society, and Midwinter in Newark as called by president.

NEW YORK

Associated Radiologists of New York, Inc.—President, Henry A. Barrett, M.D., 140 East 54th St., New York City; *President-elect*, I. J. Landsman, M.D., 910 Grand Concourse, New York City; *Vice-president*, Frederic E. Elliott, M.D., 122 76th St., Brooklyn; *Treasurer*, Solomon Fineman, M.D., 133 East 58th St., New York City; *Secretary*, William J. Francis, M.D., 210 Fifth Ave., New York City. Regular meetings the first Monday evening of the month in March, May, October, and December.

Brooklyn Roentgen Ray Society.—President, Albert Voltz, M.D., 115–120 Myrtle Avenue, Richmond Hill; *Vice-president*, A. L. L. Bell, M.D., Long Island College Hospital, Henry, Pacific, and Amity Sts., Brooklyn; *Secretary-Treasurer*, E. Mendelson, M.D., 132 Parkside Ave., Brooklyn. Meetings first Tuesday in each month at place designated by president.

Buffalo Radiological Society.—President, Chester D. Moses, M.D., 333 Linwood Ave.; *Vice-president*, Edward C. Koenig, M.D., 100 High St.; *Secretary-Treasurer*, Joseph S. Gian-Franceschi, M.D., 610 Niagara St. Meetings second Monday evening each month, October to May, inclusive.

Central New York Roentgen-ray Society.—President, J. R. Pawling, M.D., 205 Trust Co. Bldg., Watertown; *Vice-president*, A. Lenz, M.D., 613 State St., Schenectady; *Secretary-Treasurer*, Carlton F. Potter, M.D., 425 Waverly Ave., Syracuse. Meetings held in January, May, and October as called by Executive Committee.

Long Island Radiological Society.—President, Samuel G. Schenck, M.D., Brooklyn; *Vice-president*, G. Henry Koiransky, M.D., Long Island City; *Secretary*, Marcus Wiener, M.D., 1430 48th St., Brooklyn; *Treasurer*, Louis Goldfarb, M.D., 608 Ocean Ave., Brooklyn. Meetings fourth Thursday evening each month at Kings County Medical Bldg.

New York Roentgen Society.—President, Harry M. Imboden, M.D., 30 W. 59th St., New York City; *Vice-president*, Henry K. Taylor, M.D., 667 Madison Ave., New York City; *Secretary*, Roy D. Duckworth, M.D., 170 Maple Ave., White Plains, N. Y.; *Treasurer*, Eric J. Ryan, M.D., St. Luke's Hospital, New York City.

Rochester Roentgen-ray Society.—Chairman, Joseph H. Green, M.D., 277 Alexander St.; *Secretary*, S. C. Davidson, M.D., 277 Alexander St. Meetings at convenience of committee.

NORTH CAROLINA

Radiological Society of North Carolina.—President, Robert P. Noble, M.D., 127 W. Hargett St., Raleigh; *Vice-president*, A. L. Daughtridge, M.D., 144 Coast

Line St., Rocky Mount; *Secretary-Treasurer*, Major I. Fleming, M.D., 404 Falls Road, Rocky Mount. Meetings with State meeting in May, and meeting in October.

OHIO

Cleveland Radiological Society.—President, J. H. West, M.D., 10515 Carnegie Ave.; *Vice-president*, Harry Hauser, M.D., City Hospital; *Secretary-Treasurer*, H. A. Mahrer, M.D., 10515 Carnegie Ave. Meetings at 6:30 P.M. at the Mid-day Club, in the Union Commerce Bldg., on fourth Monday of each month from October to April, inclusive.

Radiological Society of the Academy of Medicine (Cincinnati Roentgenologists).—*President*, B. M. Warne, M.D., Doctors Building, Cincinnati; *Secretary-Treasurer*, Justin E. McCarthy, M.D., 707 Race St., Cincinnati, Ohio. Meetings held third Tuesday of each month.

PENNSYLVANIA

Pennsylvania Radiological Society.—President, Charles S. Caldwell, M.D., 520 S. Aiken Ave., Pittsburgh; *First Vice-president*, Thomas L. Smyth, M.D., 111 N. 8th St., Allentown; *Second Vice-president*, Reuben G. Alley, M.D., Western Pennsylvania Hospital, Pittsburgh; *Secretary-Treasurer*, Lloyd E. Wurster, M.D., 416 Pine St., Williamsport; *President-elect*, Louis A. Milkman, M.D., 212 Medical Arts Bldg., Scranton; *Editor*, William E. Reiley, M.D., Clearfield.

The Philadelphia Roentgen Ray Society.—President, H. Tuttle Stull, M.D., 3260 N. Broad St., Philadelphia, Penna.; *Vice-president*, Joseph E. Roberts, Jr., M.D., 403 Cooper St., Camden, N. J.; *Secretary*, Barton R. Young, M.D., Temple University Hospital, Philadelphia, Penna.; *Treasurer*, Fay K. Alexander, M.D., Chestnut Hill Hospital, Philadelphia, Penna.

The Pittsburgh Roentgen Society.—President, Zoe A. Johnston, M.D., 601 Jenkins Arcade; *Vice-president*, Prentiss A. Brown, M.D., and *Secretary-Treasurer*, Harold W. Jacox, M.D., 4800 Friendship Ave. Meetings held second Wednesday of each month at 4:30 P.M., from October to June at various hospitals designated by program committee.

RHODE ISLAND

See New England Roentgen Ray Society.

SOUTH CAROLINA

South Carolina X-ray Society.—President, Percy D. Hay, Jr., M.D., McLeod Infirmary, Florence; *Secretary-Treasurer*, Hillyer Rudisill, Jr., M.D., Roper Hospital, Charleston. Meetings in Charleston on first Thursday in November, also at time and place of South Carolina State Medical Association.

SOUTH DAKOTA

Meets with Minnesota Radiological Society.

TENNESSEE

Memphis Roentgen Club.—Chairmanship rotates monthly in alphabetical order. Meetings second Tuesday of each month at University Center.

Tennessee Radiological Society.—President, Steve W. Coley, M.D., Methodist Hospital, Memphis; *Vice-president*, Eugene Abercrombie, M.D., 305 Medical Arts Bldg., Knoxville; *Secretary-Treasurer*, Franklin B. Bogart, M.D., 311 Medical Bldg., Chattanooga. Meeting annually with State Medical Society in April.

TEXAS

Texas Radiological Society.—President, Jerome H. Smith, M.D., San Antonio; *President-elect*, C. F. Crain, M.D., Corpus Christi; *First Vice-president*, M. H. Glover, M.D., Wichita Falls; *Second Vice-president*, G. D. Carlson, M.D., Dallas; *Secretary-Treasurer*, Henry C. Harrell, M.D., 517 Pine St., Texarkana. Meets annually. Temple is place of next meeting.

VERMONT

See New England Roentgen Ray Society.

VIRGINIA

Radiological Society of Virginia.—President, Fred M. Hodges, M.D., 100 W. Franklin St., Richmond; *Vice-president*, L. F. Magruder, M.D., Raleigh and College Aves., Norfolk; *Secretary*, V. W. Archer, M.D., University of Virginia Hospital, Charlottesville.

WASHINGTON

Washington State Radiological Society.—President, H. E. Nichols, M.D., Stimson Bldg., Seattle; *Secretary*, T. T. Dawson, M.D., Fourth and Pike Bldg., Seattle. Meetings fourth Monday of each month at College Club.

WISCONSIN

Milwaukee Roentgen Ray Society.—President, H. W. Hefke, M.D.; *Vice-president*, Frederick C. Christensen, M.D.; *Secretary-Treasurer*, Irving I. Cowan, M.D., Mount Sinai Hospital, Milwaukee. Meets monthly on first Friday at the University Club.

Radiological Section of the Wisconsin State Medical Society.—Secretary, Russel F. Wilson, M.D., Beloit Municipal Hospital, Beloit. Two-day annual meeting in May and one day in connection with annual meeting of State Medical Society, in September.

University of Wisconsin Radiological Conference.—Secretary, E. A. Pohle, M.D., 1300 University Ave., Madison, Wis. Meets every Thursday from 4 to 5 P.M., Room 301, Service Memorial Institute.

EDITORIAL

LEON J. MENVILLE, M.D., *Editor*

HOWARD P. DOUB, M.D., *Associate Editor*

COSTS AND FEES

A fruitful topic of conversation among medical men who are inclined to be critical is the high cost of radiological work, especially that done in connection with diagnosis. That it is frequently an expensive procedure for persons of moderate or less than moderate means must be admitted. Those of us who do the work and pay the operative and other costs will also agree that it is expensive to do. All of us who are interested in radiological diagnosis are constantly faced with the problem of attempting to bring the cost to the patient down to his financial ability.

It is probably true that, in most parts of the country, the average fees collected for radiological diagnosis are lower than they used to be. On the other hand, however, the ability to lower fees and extend the benefits of radiological diagnosis to greater numbers of persons has been definitely limited by increasing costs to the radiologist. For the most part, labor costs are no less, probably salaries are a little better than they used to be, certainly the salaries of first-class technicians are. Films and related supplies have not gone down in price appreciably in twenty years. Apparatus is no cheaper; on the contrary, both it and tubes are certainly more expensive. It must be admitted, however, that they are both immeasurably superior to the old tubes and apparatus. They have generally longer life and certainly are much more efficient, but the increased cost counterbalances the above advantage to some extent at least.

The greatest increase in cost is probably the result of the more elaborate and time-consuming procedures that have become standard and necessary, and while new procedures have opened up many new fields for radiological diagnosis, the majority of these are costly. Among these is the radiological diagnosis of cerebral and genito-urinary lesions. The ordinary fee that is available from the patient who has a thorough study by means of ventriculograms or encephalograms or who has an intravenous or retrograde pyelography is frequently hardly more than adequate to pay the actual technical and operating expense. Erect pyelograms, which have come into general use along with the supine procedures, mean added time and added expense, as well as new and more expensive equipment. The use of shock-proof equipment, which is generally recognized now as standard and with which we are all replacing our old exposed tubes and overhead systems, has raised costs appreciably. This does not mean that they are not more desirable and probably worth what they cost, but it does add a definite difficulty to the problem of furnishing adequate work done with adequate equipment and help, for less money.

The best answer to the problem of fees adjustable downward is probably volume. From a practical standpoint, there are two difficulties here. One is the very definite competition of small private laboratories in the offices of internists, orthopedists, urologists, and others, in which the work is done by a part-time technician of questionable ability, who turns out work of questionable value both from a technical and a professional standpoint. The inroad on the qualified specialist's practice by this type of competition is no small matter. The unfortunate part of the situation is that in spite of all the efforts of qualified specialists to educate the general profession to distinguish between good and poor work, even only technical work, the ordinary doctor seems totally unable to make the distinction or to appreciate it.

With regard to the other difficulty, many of us wonder just how much procedures can be shortened and simplified and supervision spread out on a kind of mass production basis, and still

not fail to reach some definite necessary minimum standard of performance. In other words, of what does a necessary minimum diagnostic performance consist? We must not forget the principle that a diagnostic procedure is safe and reliable only when it is exhausted. Observation of the methods used in various presumably first-class laboratories throughout the country lead one quite definitely to the conclusion that there is very little agreement as to what is a standard necessary procedure. The methods and the standards thought acceptable, it would seem to the writer, are dictated frequently by economic factors and limitations rather than by definite professional standards, as they should be. One inquires as to whether a careful study of this problem by a qualified group of radiologists might not be of distinct value and benefit alike to the radiologist, the attending physician, and the patient.

RAYMOND G. TAYLOR, M.D.

ANNOUNCEMENTS

NEXT ANNUAL MEETING

The Committee on Publicity and Education wishes to remind the membership of the Radiological Society of North America of the Second Annual Refresher Post-graduate Series to be given in conjunction with the Annual Meeting in Atlanta, December 10–15 of this year.

As previously announced, the clinics, ordinarily a part of the Annual Meeting, will not be offered this year. In their place the Refresher Series will be given on Sunday afternoon and evening and from 8 A.M. to 10 A.M.. each day of the meeting. Several courses, including Radiology of the Chest, Radiology of the Gastro-intestinal Tract, Radiology of Bone Tumors, Radiation Physics, Radiology of Sinuses and Mastoids, Roentgen Analysis of Fractures, and a few others will be offered sequentially from Sunday through Friday. In addition, a larger series of related short subjects will also be offered.

There will be no charge for registration and members of the Society will be given preference.

The Committee urges that the members plan early to attend the entire series, so that the faculty of nationally known teachers will feel repaid for their effort in offering the courses.

THE AMERICAN BOARD OF RADIOLOGY

The next examination of the American Board of Radiology will be held in Atlanta, Georgia, December 9, 10, and 11, 1939. Those wishing to receive appointments for this examination should have their applications in the office of the Secretary not later than September 1. There will also be an examination in New York City in June, 1940, just preceding the meeting of the American Medical Association.

There will *not* be an examination in Chicago at the time of the meeting of the American Roentgen Ray Society.

B. R. KIRKLIN, M.D., *Secretary*

COMMUNICATIONS

RADIOLOGY AND THE GENERAL PUBLIC

A Brief Description of the Pacific Roentgen Club's Educational Exhibit at the San Francisco Golden Gate International Exposition

The California World's Fair, or Golden Gate International Exposition, was created to commemorate the completion of the two bridges spanning San Francisco Bay, two remarkable feats in modern bridge engineering. The main portion of the Fair consists of twelve large buildings set amongst extensive gardens and lakes. One of the first of these buildings is the Hall of Science, with a floor space of approximately 50,000 square feet. The exhibits therein are devoted to "Research in Human Progress," over one-half being related to medical science. The following American scientific societies have exhibits: The American Medical Association, the California Medical Association, the American and California Associations for the Advancement of Science, the American Dental Association, the California Tuberculosis and Heart Associations, the American National Red Cross, the California State Department of Health, the Mayo Clinic, the Pacific Roentgen Club, and others. In most of these exhibits, roentgenograms form significant parts of the display.

It was only shortly before the Fair opened that the Pacific Roentgen Club was invited to create an exhibit for a large booth which was still unoccupied (1,500 square feet). A special

committee of the Club, under the Chairmanship of Harold A. Hill, M.D., went to work immediately and in less than two weeks created

Fig. 1. The Pacific Roentgen Club Exhibit at the California World's Fair. Portion of the front of the exhibit booth. (*Note:* This and the following photographs were made at "closing time" at which hour the public has largely vacated the pavilions.)

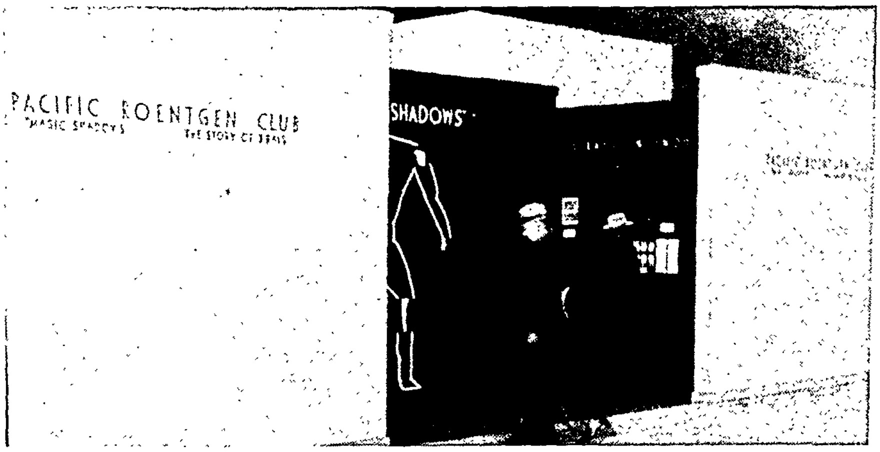

Fig. 2. View of the front portion of the exhibit.

an exhibit which, to our surprise, has been one of the most popular in the Hall of Science. The exhibit is entitled "Magic Shadows: The Story of X-ray." It shows, by the use of approximately seventy roentgenograms, diagrams, and photographs, the nature and usefulness of x-rays in modern medical diagnosis and treatment.

There are five main panels. In the first panel, a comparison is made between radiography and photography, with clear explanations of both. In the second section, illustrations are provided showing the uses of x-rays in anatomy. In the third section is shown the uses of x-rays in obstetrics and pediatrics. In the fourth section, the uses of x-rays in the diagnosis and treatment of tumors, and in the fifth, a brief exhibit of the uses of x-rays in industry itself. Although the exhibit is silent and without regular attendants, it has proved to be one of the main attractions in the Hall of Science.

No equipment is exhibited, chiefly because it is desired to emphasize the fact that medical training in radiology is more important than equipment in the medical application of x-rays. The attendance and interest, as above stated, have been far greater than anticipated, and it

is believed that considerable public education will be the result.

The Local Committee responsible for the exhibit, to whom great credit is due, is composed of: Harold A. Hill, M.D., Frederick H. Rodenbaugh, M.D., Charles Capp, M.D., Maurice Robinson, M.D., Robert R. Newell, M.D., Edward Leef, M.D., Arthur Williams, M.D., and Charles Fulmer, M.D. The following physicians, technicians, and volunteers also

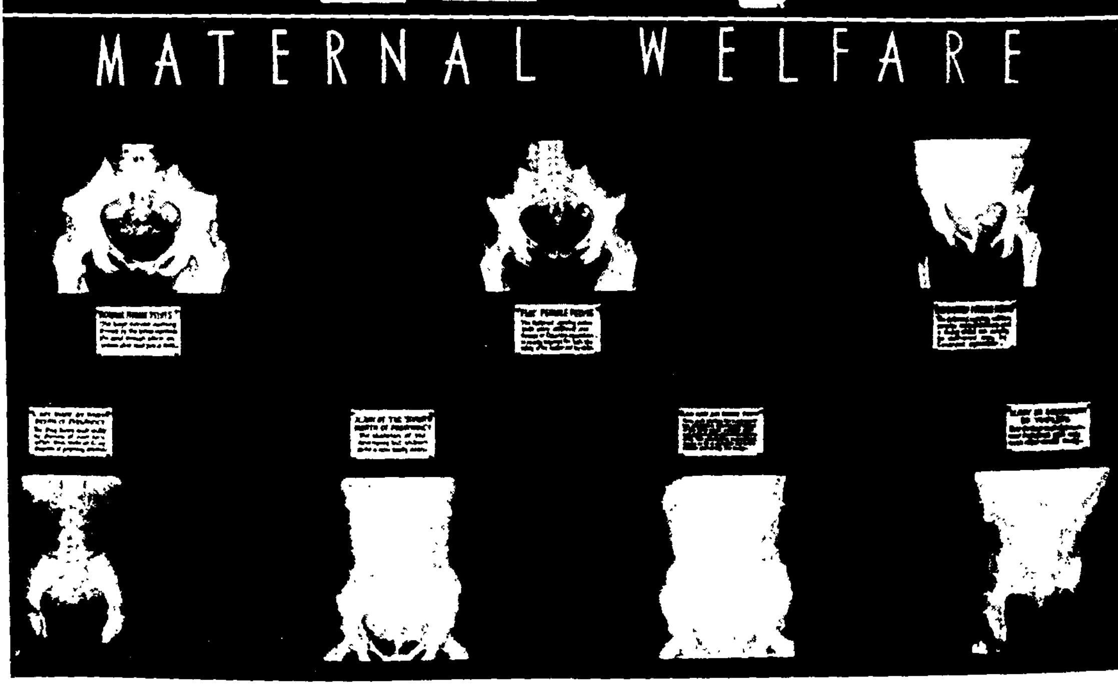

Fig. 3 (*above*). Portion of the panel showing uses of x-rays in diseases of children.
Fig. 4 (*below*). Portion of the panel showing uses of x-rays in maternal welfare.

rendered invaluable assistance in the installation of the exhibit: A. Petrilli, M.D., Edith Miller, M.D., Maurice Sachs, M.D., and Marjorie Mottram, M.D.; Messrs. E. N. Dudman and C. Wiethaup, Mrs. Dudman, and Miss Comfort. This Committee received great help from Dr. Milton Silverman, the Director of the Hall of Science, without whose advice and cooperation the exhibit could never have been completed.

L. H. GARLAND, M.D.

SPECIAL POST-GRADUATE COURSES FOR RADIOLOGISTS

The University of Minnesota is offering a series of special three-day post-graduate courses for radiologists. They will be given at the Center for Continuation Study, the exclusive residence and classroom building for post-graduate students on the main campus, Minneapolis. The special series for radiologists is part of the general post-graduate program. Since Jan. 1, 1937, more than 1,200 registrants have attended the 38 medical and hospital post-graduate courses which have been given by the Department of Post-graduate Medical Education under the direction of William A. O'Brien, M.D. For the past year, the program has been assisted by a special grant from the Commonwealth Fund, New York. With this new development the University of Minnesota now has three divisions in the Medical School—undergraduate, graduate, and post-graduate.

The first course in the special series for radiologists was in Radiation Physics on June 12, 13, and 14, 1939. The program was arranged and directed by K. W. Stenstrom, Ph.D., Professor of Biophysics and Director of the Division of Radiation Therapy, University of Minnesota. In addition to Dr. Stenstrom, the faculty included Lauriston S. Taylor, Physicist, National Bureau of Standards, United States Department of Commerce, Washington, D. C.; Ernst A. Pohle, M.D., Ph.D., Professor of Radiology, University of Wisconsin; Otto Glasser, Ph.D., Biophysicist, Cleveland Clinic; Arthur U. Desjardins, M.D., Professor of Radiology, Mayo Foundation; Marvin M. D. Williams, Ph.D., Instructor in Biophysics, Mayo Foundation; J. William Buchta, Ph.D., Professor and Chairman of Physics Department; Leo G. Rigler, M.D., Professor and Head of Radiology; Edward Schons, M.D., Special Lecturer, General Extension Division; John T. Tate, Ph.D., *Professor of Physics*; Joseph Valasek, Ph.D., Associate Professor of Physics; Irwin Vigness, Ph.D., Instructor in Biophysics; John H. Williams, Ph.D., Associate Professor of Physics—all of the University of Minnesota.

The subjects were presented in the form of lectures, demonstrations, and question-and-answer periods. They included History of Roentgen, Atomic Structure, Artificial Radioactivity, Radiologic Diagnosis, Quality and Quantity of Roentgen Rays, Diffraction, Refraction, Reflection and Spectroscopy, Absorption of Roentgen Rays, Van de Graaff Apparatus, Biological Factors, Radiation Biology, Radiologic Protection, Dosage Measurements, Radiologic Therapy, and Demonstration of 1,200-kilovolt Treatment Apparatus.

The next course in the special series for radiologists will deal with Roentgenologic Diagnosis of Diseases of the Nervous System. The date will be announced in the near future. It will occupy the full time of those in attendance from 8:30 A.M. to 8:30 P.M. on each of the three days. A concentrated schedule is made possible by holding the course in the same building in which the physicians will live. The entire building will be reserved for the group. The tuition for each three-day special radiologic course will be $15.00. An average single room and all meals is $8.25 for the three days. Use of the garage is $0.50 a day, and there are no other extras. The faculty will include members of the faculty of the undergraduate and graduate schools, Mayo Foundation, and distinguished radiologists from other medical centers. Enrollment in each course will be limited to the number who can best profit by the instruction. Only radiologists will be admitted.

Further information may be obtained from William A. O'Brien, M.D., Director, Department of Post-graduate Medical Education, University of Minnesota, Minneapolis, Minnesota.

ADVISORY COUNCIL ON MEDICAL EDUCATION

The Advisory Council on Medical Education was created to-day [June 24, 1939] at a meeting in Chicago by eleven national organizations concerned with the training of physi-

Following a short chapter on physical and technical principles which include a clever schematic illustration of the photographic process from exposure to final roentgenogram, the diagnostic roentgenology of bones and joints, lung, heart, aorta, digestive tract, gall bladder, pancreas, and genito-urinary tract is discussed. A large portion of the available space is devoted to the skeleton, its normal appearance in the roentgenogram, and its pathological conditions, thus leaving relatively little room for the remaining organs and organ systems. The fundamentals of roentgen therapy are outlined in 17 pages and, though of necessity brief, are presented in a concise manner and suffice for the beginner. The illustrations are well executed, and as a first introduction to roentgenology this book can be recommended.

END-RESULTS IN THE TREATMENT OF GASTRIC CANCER. By EDWARD M. LIVINGSTON, B.Sc., M.D., Associate Visiting Surgeon, Bellevue Hospital, New York; Assistant Clinical Professor of Surgery, New York University College of Medicine; formerly Visiting Surgeon, New York City Cancer Institute, and GEORGE T. PACK, B.Sc., M.D., F A.C.S., Attending Surgeon, Memorial Hospital, New York City; Assistant Professor of Clinical Surgery, The School of Medicine, Yale University, New Haven, and Cornell University Medical College, New York City. A volume of 179 pages with 30 charts and six figures. Published by Paul B. Hoeber, Inc., New York City, 1939. Price: $3.00.

The monograph serves a very useful purpose in presenting the various operability and mortality rates in cases of carcinoma of the stomach. Special charts and tables show the mortality rates in a collected series of 12,000 cases in which partial gastrectomy was performed and the average rates in reports from all sources and in all periods. A natural "yardstick" is given for the measure of the cures. Results of special follow-up studies made three, five, and ten years after operation are given.

There is an excellent foreword by Bowman C. Crowell, M.D., Associate Director, American College of Surgeons, who states that "the numerical importance of gastric cancers places this study among the most significant that could have been made in the cancer field in the present state of our knowledge of the subject... Surgeon, internist, radiologist, and general practitioner should profit from this study."

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GENITO-URINARY TRACT (THERAPY)

Spermatocele, Including its X-ray Treatment. Charles Huggins and W. J. Noonan. Jour. Urol., **39**, 784–790, June, 1938.

The authors present eight cases of spermatocele treated by 600 roentgens in two or three treatments at one- or two-day intervals. They found that the spermatocele always disappeared following x-ray therapy to the involved testis and without loss of sexual potency or libido.

Because sterilization occurs, x-ray therapy is advised only in cases in which fertility is undesirable, as in older men.

JOHN G. MENVILLE, M.D.

Intravenous Urography. Fred M. Hodges. South. Med. Jour., **32**, 150–154, February, 1939.

Sufficient use is not being made of intravenous urography. Care and proper technic are indispensable to a satisfactory examination. Frequent examinations will disclose unsuspected and unexpected kidney lesions. Intravenous urography is particularly useful in obscure abdominal cases and in patients in whom the symptoms are not severe enough to justify a general urologic examination.

JOHN M. MILES, M.D.

Roentgen and Radium Therapy in Affections of the Genito-urinary Tract in the Male. Alessandro Bianchini. Arch. di Radiol., **14**, 30–68, January-February, 1938.

This is a review of the modern views of the value of radiotherapy in urology. Although the subject is well presented it could be improved by a bibliography.

E. T. LEDDY, M.D.

Cystography, Especially Pneumocystography, as a Guide in Treatment of Vesical Neck Lesions. T. H. Sweetser. Jour. Urol., **40**, 285–293, August, 1938.

The author stresses the fact that proper interpretation of cystography in association with digital rectal examination with a catheter in place affords not only valuable information but permits one to plan the method of treatment with almost no disturbance of the patient.

Cystograms were made with from 30 to 90 c.c. of air, from 30 to 90 c.c. of 1.5 per cent sodium iodide, and a small amount of stronger skiodan. There are 24 illustrations.

JOHN G. MENVILLE, M.D.

GRANULOMA

Gangrenescent Granuloma and its Treatment with Vitamin C and Roentgen Rays. E. Heinermann. München. med. Wchnschr., **85**, 2023, 2024, Dec. 30, 1938.

This disease was first described by Wirth and Henning and by Kraus. It is rare (28 reported cases) and found mostly in males. It generally starts in the nasal cavity, but may originate in the soft palate, throat, or mucosa of the cheeks. The course runs from two months to five years, and leads to a fatal termination through cachexia, sepsis, pneumonia, erysipelas, meningitis, brain abscess, or hemorrhage. The gangrenous destruction leads to an ulcer with steep, slightly elevated walls with a bluish-red base and rather firm consistency. The surrounding centimeter of tissue is infiltrated, slightly elevated, and reddened. The general condition is poor, and fever is always present. The blood picture is not characteristic. Bacteriologic studies show a mixed group of non-pathogenic diphtheroids, staphylococci, and streptococci. Glanders, anthrax, tubercle bacilli, and spirochetes were not found. Regional glands are not usually enlarged, and the disease progresses deeply, to the bone at times. The etiology is unknown. Treatment has been by irradiation, anti-syphilitic therapy, detoxin, potassium iodide, and radical surgery with irradiation.

A case of a girl, 20 years of age, is reported, in which a vitamin C deficiency was discovered. Treatment with 5 c.c. cebione a day, intravenously, plus cebione tablets, combined with irradiation (2,500 r total to each of three fields, two lateral and one posteriorly about the neck, 10 × 15 cm. in size, 40 cm. F.S.D., 0.5 mm. Cu filter, 180 kv., 150 per field daily) resulted in a cure, complicated, however, by a pharyngeal stenosis. This was successfully dilated with bougies, and the patient has been symptom-free for over a year.

LEWIS G. JACOBS, M.D.

HEART AND VASCULAR SYSTEM

Rupture of the Right Auricle. R. Nicolini, A. Battro, and R. Latienda. Rev. Argent. de Cardiol., **5**, 182–187, July and August, 1938.

Ruptures of the cardiac chambers are comparatively rare. Up to 1938, only 710 cases had been reported. The left ventricle is the chamber most frequently ruptured, then the right, and finally the auricles. Clowe, Kellert, and Gorham, however, collected 55 cases of ruptures of the cardiac muscle but none of these was of the ventricles.

The authors believe that coronary infarcts are the cause of all non-traumatic ruptures.

The article presents a case report of a 57-year-old male whose only complaint was pain in the gall-bladder region appearing four hours after meals every sixth or seventh day. The heart was essentially negative; the lungs revealed friction rubs and sibilant râles. There was tumefaction in the region of the gall bladder. Cholecystograms revealed calculous cholecystitis. Some blood and a few pus cells were found in the urine. Urea, blood sugar, and blood count were negative. The Wassermann test was negative. The clinical diagnosis was cholecystitis.

A cholecystectomy was done. The day following, the patient suffered a sudden circulatory collapse with high pulse (rate 145) and low arterial tension. He did not rally and died 14 hours later.

Autopsy revealed a new moon-shaped rupture of the right auricle with an extensive hemo-pericarditis that caused death by compression of the heart muscle. The correct diagnosis was not made before death.

ANTONIO MAYORAL, M.D.

Dissecting Aneurysms of the Aorta and the Iliac Artery, with an Unusual Case of Spurious Aneurysm. Sven Roland Kjellberg. Acta Radiol., **19**, 273–284, September, 1938.

Two cases of dissecting aneurysms of the abdominal aorta and a case of aneurysm of the iliac artery were diagnosed by x-ray examination. In all three cases retroperitoneal hemorrhage had obscured the outlines of the psoas muscles and of the kidney. Calcareous plaques in the wall of the aneurysm further aided in the radiological diagnosis.

In the case of spurious aneurysm, a rounded hernia-like protrusion of the posterior portion of the diaphragm had simulated a tumor.

ERNST A. SCHMIDT, M.D.

Rheumatic Heart Disease in Children. Jerome G. Kaufman. Jour. Med. Soc. New Jersey, **35**, 525–531, September, 1938.

This paper is primarily a clinical study of the rheumatic heart. A roentgenographic analysis of an apparently large series in children reveals, in the following sequence: (1) An accentuation of the left auricle; (2) A straightening of the left auriculo-pulmonic curve due to the enlargement of the conus and pulmonary artery, and (3) A further enlargement of the auricle posteriorly and to the right, with an encroachment on the esophagus and diminution of the retrocardiac space.

The right auricle may also be enlarged, especially in stenosis, but the left ventricle may or may not be enlarged, depending on the type and degree of lesion. Because of the straightening of the left auriculo-pulmonic curve, the aortic knob appears receded and the descending aorta may be obscured.

The author cautions against the error of confusing long-rotated, narrow, dropped heart with a mitral configuration. Even a straightening of the auriculo-pulmonic curve may be seen in such cases.

In the combined lesions, the left ventricle becomes enlarged; the apex tends to point downward, and the long axis of the ventricle becomes more oblique.

MAX MASS, M.D.

HEMORRHAGE

Extradural Hemorrhage. K. G. McKenzie. British Jour. Surg., **26**, 346–365, October, 1938.

Extradural hemorrhage usually arises from a rupture of the anterior branch of the middle meningeal artery. It is an infrequent lesion and the author reports 20 cases which he has seen during the past 10 years. The syndrome is characterized by a lucid interval following a short period of immediate partial or complete unconsciousness. The lucid interval may be prolonged and confuse the diagnosis. There are three important lateralizing signs:

(1) Edema of the scalp in the temporal fossa, suggesting a linear fracture which can be confirmed by x-ray examination.

(2) A dilated fixed pupil on the side of the lesion.

(3) A positive Babinski and diminution of active movement of the arm and leg on the side opposite to the lesion.

In this series of 20 cases there was fracture on the side of the lesion in 19 cases and in one case there was no fracture. Extradural hemorrhage rarely occurs without fracture, and absence of a linear fracture in x-ray films is strong evidence against this lesion.

The cerebrospinal fluid is clear or faintly blood-tinged. If it is very bloody, the diagnosis is in doubt, as the syndrome may be produced by the bruising or laceration of the brain.

Extradural hemorrhage is a serious lesion and the mortality rate will be high unless there is accurate early diagnosis and prompt treatment.

MAX CLIMAN, M.D.

THE HIP JOINT

Hip Deformities in Adults. F. Campbell Golding. Proc. Royal Soc. Med., **31**, 940–942, June, 1938.

Deformities such as are described in this article may be recently acquired, or may follow juvenile disease. Congenital dislocation, pseudo-coxalgia, slipped epiphysis, and old infections of the hip will almost certainly have osteo-arthritis engrafted upon their deformities.

Tuberculosis of the hip has its maximum age incidence between three and seven years, and is not common in the adult. In deciding whether or not there has been infantile tuberculosis we consider that after that disease—

1. Complete and perfect ankylosis is unlikely, except by secondary infection or operation, because healing is slow and incomplete.

2. Trabeculations are dense and widely spaced, and the joint below the site of disease is similarly affected.

3. Small, irregular, dense, homogeneous calcifications tend to persist indefinitely at the joint space.

Metaphyseal and ischial lesions of tuberculosis must be distinguished from those of osteomyelitis and cyst.

Gonococcal infection is illustrated by a case resembling coxa plana. Pathognomonic features are not available, and diagnosis is difficult.

The diagnosis of Charcot's joint is usually fairly obvious. Early stages may be seen by radiographing asymptomatic joints of patients having a frank lesion. Fifty per cent of the author's cases were Wassermann-negative reactions. Both hypertrophic and atrophic manifestations are seen, one of the author's patients

having hypertrophic changes in one joint and atrophic in another.

Orthopedic devices frequently make the examination of cases of trauma difficult. A case is illustrated in which, after dislocation, many osteophytes formed in soft tissues about the hip.

Protrusio acetabuli depends only on malacias of the acetabulum, which may be classified as (1) destructive disease such as syphilis, tuberculosis, Paget's disease, sepsis, neoplasm, or echinococcus; (2) the rheumatic group which includes non-specific infection, rheumatoid arthritis, gonorrhea, and, questionably so grouped, osteo-arthritis, and (3) a peculiar group of unknown etiology, thought to arise early in life, featuring a thin acetabular wall and intact cartilage. The head may be deeply buried. The deformity, once established, does not appear to increase. Etiology is unknown. The author is unable to accept the usual theory of traumatic origin in 23 of his cases.

Rheumatoid arthritis features partial or complete loss of cartilage, general subchondral changes, decalcification of senile type, and great similarity of appearance in all cases.

Osteo-arthritis features loss of cartilage at the weight-bearing points, sclerosis and new formation of bone, cavitation of bone, a tendency of the head to move out of the acetabulum, and deposition of new bone in the acetabulum forming on the head of the femur. Considering the discussion, whether the displacement of the head precedes or follows the deposition, the author cites that 53 per cent of his cases had displacement and 39 per cent deposition. This may indicate that displacement comes first.

Ray A. Carter, M.D.

HODGKIN'S DISEASE

Hodgkin's Disease and Allied Disorders. Henry Jackson, Jr. New England Jour. Med., **220**, 26–30, Jan. 5, 1939.

Hodgkin's disease and its allied disorders may be grouped collectively under the term of malignant lymphoma and include Hodgkin's disease, lymphosarcoma, reticulum-cell sarcoma, and giant-follicle lymphoma.

In lymphosarcoma, the lymph node is diffusely invaded by lymphocytes, mostly mature. The capsule and adjacent structures may be invaded, and the blood may show a lymphatic leukemic state.

Reticulum-cell sarcoma shows large, pale, ameboid cells with irregular outline and a vesicular nucleus. Eosinophils are not found, fibrosis is rare, but invasion occurs.

In Hodgkin's lymphoma, the lymph node structure is replaced by a diffusion of mature lymphocytes with scattered Reed-Sternberg cells. Neither eosinophilia, fibrosis, nor necrosis occurs.

Hodgkin's granuloma shows fibrosis, eosinophilia, necrosis with neutrophils, and Reed-Sternberg cells.

Hodgkin's sarcoma shows invasion of tissue with large cells of uniform size and basophilic cytoplasm. The nuclei are round with a prominent nucleolus. Eosinophils are not found but Reed-Sternberg cells are present.

Giant-cell lymphoma presents lymph nodes with widely scattered germinal centers composed of uniform rapidly growing cells of uncertain origin. Necrosis, neutrophilia, and phagocytosis are absent. This condition may evolve into one of the other allied disorders.

The etiology of this group of disorders remains unknown. There is no limitation to age groups. Males are more frequently affected than females.

Any organ or tissue may be involved in these processes but the lymph nodes are most frequently affected. Secondary involvement of bone occurs in 25 per cent of Hodgkin's disease. Malignant lymphoma of some form involves the gastro-intestinal tract in 25 per cent of the cases. Mediastinal involvement is frequent.

Symptomatology is variable as might be expected. Lymph node enlargement, pain, fatigue, sore throat, dyspnea, cough, fever, weight loss, generalized itching, and amenorrhea are usual symptoms. Blood examination is rarely of help. Biopsy is essential to diagnosis.

Surgery alone may rarely be of value. Irradiation is the standard method of treatment but should be under the direction of a competent radiotherapist. No preference as to restricted or generalized irradiation is had. It is recommended that from 200 to 800 r at 250 kv. be given in divided doses, treating when node enlargement is present.

It is firmly believed that irradiation prolongs life, and adds to the comfort of these patients. Supportive treatment is insisted upon. The average length of life of these patients after onset of the disease is two and one-half years, but some patients have lived more than ten years. Hodgkin's lymphoma has the best life expectancy with 20 per cent living ten years.

J. B. McAneny, M.D.

A Case of Hodgkin's Disease with Massive Collapse and Cavitation of the Lung. B. L. Hardin, Jr. Am. Jour. Med. Sci., **197**, 92–99, January, 1939.

Although compression of the superior vena cava and trachea occur so often in Hodgkin's disease, partial or complete bronchial occlusion by enlarged bronchial or mediastinal nodes are uncommon. When this condition is found, the obstruction is not due to extra-bronchial pressure, but to endobronchial protrusion of granulomatous placques.

The first case of massive pulmonary collapse due to Hodgkin's disease, reported in 1932, was due to invasion of the left main bronchus from a huge mass of nodes about the tracheal bifurcation. The second case, reported in 1934, was due to an endobronchial polyp made up of Hodgkin's tissue. A large pleural effusion was present in each case.

In this article a case of Hodgkin's disease is reported in which pulmonary excavation and massive collapse

occurred, the bronchial constriction being due to granulomatous infiltration. The mechanism of the cavitation was not clear. Although excavation, when it occurs in Hodgkin's disease, has been considered to be due to radiotherapy, it has also been described as occurring spontaneously. In this case cavities also occurred in the untreated lung.

The variability of the atelectasis was an interesting feature in this case. The accumulation of mucus behind the constriction at times rendered the all but complete obstruction wholly so.

Although the bronchitis which occurs may be regarded by the pathologist as a simple acute or simple chronic form, frequently its specific nature is suggested by the placque-like opacities in various portions of the mucosa, or by the elevated areas or bulky nodular outgrowths which narrow the lumen considerably.

BENJAMIN COPLEMAN, M.D.

INDUSTRIAL DISEASES

Radiological Demonstration of Pathological Changes Induced by Certain Industrial Processes. James F. Brailsford. British Jour. Radiol., **11**, 393–400, June, 1938.

Disease process due to industrial causes may be missed because affected workers have different doctors. The radiologist holds an unique position in this capacity as he may correlate the findings in a great number of patients. One important recent discovery in this respect has been that of the effect of fluorine on the bones of workers, particularly in workers in cryolite. The first changes are noticed only in the pelvis and lumbar spine, which show a slight increase in density. The trabeculæ appear rough and blurred. Later the cancellous structure appears to fuse so that a dense structureless film is observed. Still later the bone presents a diffuse marble-white shadow, in which details cannot be distinguished. When this supervenes, changes are seen in all the bones. Irregular periosteal excrescences are seen frequently. The degree of change depends roughly upon the length of time the worker has been working with fluorine. The first signs were discovered in workers who had been working for about nine years. There are numerous exceptions to this time period, due to the different concentrations of the dust. In spite of these bone changes in cryolite workers, the morbidity was not any higher than in other industries.

All patients who have injury to bones or joints, even minor ones, should be x-rayed as soon as possible after the injury. Not infrequently radiographic evidence at a later date suggests that the lesion was present before the injury and that trauma had done little more than call attention to it. Bone changes may take place as the result of repeated small grades of trauma which are, in themselves, insufficient to produce injury. Therefore, it is important to have early and frequent radiographic examinations.

Radiographs of the lungs of workers who are entering an employment in which there are apt to be changes due to the inhalation of dust, should be made at the beginning of employment. Such an examination may be invaluable later in assessing the amount of change due to dust inhalation. It is not possible to fix the degree of disability from the x-ray examination of silicosis cases. It is frequently found that patients with advanced changes evidenced by roentgen-ray examination show little or no clinical symptoms, and, conversely, it usually happens that a patient shows very little change on the x-ray examination but may have profound disability.

SYDNEY J. HAWLEY, M.D.

THE INTESTINES

Duration of Intestinal Transit in the Normal Individual. Guénaux and Vasselle. Bull. et mém. Soc. de radiol. méd. de France, **26**, 319–324, May, 1938.

Investigations of normal individuals with opaque meals have shown that there is a period of filling of the colon and a period of evacuation. A given meal does not pass through the intestine as a whole; it is divided into parts. The evacuation of a given day's meals requires two stools, one from 12 to 24 hours, the other from 36 to 44 hours after ingestion. The maximum time is 48 hours and this limit marks the division between the normal state and a state of constipation.

S. R. BEATTY, M.D.

The Roentgen Diagnosis of Intestinal Obstruction. Andreas Hoyer. Acta Radiol., **19**, 409–432, November, 1938.

Hoyer describes his technic in the determination of intestinal obstruction which enabled him to give a correct diagnosis in 100 per cent of his cases. Both fluoroscopy and radiography are used with the patient in the erect position. In all cases the examination by contrast medium could be dispensed with, and in the majority of cases the site of lesion could be ascertained fairly accurately. The interpretation of the x-ray appearance relied on the characteristic findings of fluid levels in the occluded intestines. In addition, the importance of gas accumulation, especially in the colon, is emphasized. In contradistinction to the clinical symptoms which are frequently vague and inconclusive in the initial stages of the disease, the x-ray examination is able to furnish valuable conclusions concerning presence and location of intestinal obstruction a very short time after its onset.

ERNST A. SCHMIDT, M.D.

Emphysema of the Cecum and Ascending Colon. George Strenger. Jour. Am. Med. Assn., **110**, 1663, 1664, May 14, 1938.

This is a rare condition, there being only 95 reported cases. Other names for this medical rarity are "cystic pneumatosis," "pneumatosis cystoides," and "gas cysts of the bowel." The occurrence of a similar disturbance in the intestine of swine has been known since the early eighteenth century.

When the cecum is affected the intestine is covered

with many minute vesicles, its wall being greatly thickened and crepitant, having the feel of lung tissue. In the jejunum and ileum the gas cysts are usually larger, and may hang from the intestine and mesentery in grape-like clusters. These gas spaces or cysts are most numerous under the serosa and mucosa, although they are scattered throughout all the coats of the intestine. Microscopically they are lined with flattened endothelial-like cells and are surrounded by giant cells and lymphocytes. Usually there is some associated condition such as a peptic ulcer, tuberculosis, or ulcer of the cecum.

The pathogenesis of this bizarre condition is obscure. The most plausible etiologic theory is the mechanical one, postulating that gas is forced into the wall of the intestine through an ulcer or fissure in the mucosa. Of 42 published cases, 32 were associated with ulcers in the stomach or duodenum.

Peristaltic action forced the gas through the mucosal "breaks" into the other layers of the intestine.

Emphysema of the intestine has never been diagnosed pre-operatively. In the majority of cases the clinical diagnosis was intussusception or appendical abscess.

CHARLES G. SUTHERLAND, M.D.

Co-existence of "Common Mesentery" and Spontaneous Pneumothorax in a Patient with Duodenal Stenosis Due to Compression by the Gall Bladder. J. Jalet and M. André. Bull. et mém. Soc. de radiol. méd. de France, **26**, 451–453, July, 1938.

The authors describe their findings in a case of duodenal stenosis due to pressure of the gall bladder on the third part of the duodenum, which was situated on the right. Further examination revealed that the small intestine was entirely to the right of the midline, the large bowel occupying the left half of the peritoneal cavity. Incidentally, the patient was found to have a partial pneumothorax which later became complete. Relief from symptoms due to the duodenal stenosis followed surgery.

S. R. BEATTY, M.D.

A Case of Intestinal Invagination Reduced by a Barium Enema. J. Nebout, E. Dechambre, and S. Dechambre. Bull. et mém. Soc. de radiol. méd. de France, **26**, 377–379, May, 1938.

The authors relate their experience in reducing an ilio-colic invagination in an infant ten months of age. Fluoroscopic and radiographic observation assisted in a successful reduction. An attempt at reduction of an invagination is justified in every case, as the procedure, if unsuccessful as a therapeutic measure, is a valuable diagnostic aid.

S. R. BEATTY, M.D.

A Case of Complete Volvulus of the Sigmoid without Strangulation and with Insignificant Symptoms. Bengt S. Holmgren. Acta Radiol., **19**, 230–238, September, 1938.

The author describes a case of a 360 degree volvulus of the sigmoid in which neither strangulation nor meteorism was present. The patient complained of constipation of several years' standing. In addition to the acute volvulus, an ulcer of the duodenal bulb was discovered by roentgen examination. Reduction of the volvulus was accomplished by means of a barium enema under fluoroscopic guidance. Holmgren points out that chronic and subacute conditions of volvulus are probably considerably more frequent that is ordinarily assumed.

ERNST A. SCHMIDT, M.D.

An Unusual Case of Intestinal Obstruction. Walter O. Paulson and L. M. Garrett. Wisconsin Med. Jour., **37**, 1001–1004, November, 1938.

The authors report a case of intestinal obstruction in a new-born infant due to a congenital membrane in the jejunum. Roentgen examination four days after birth revealed a dilated stomach, a wide dilatation of the duodenum, and a short segment of jejunum, ending in a complete obstruction. Autopsy showed the obstruction to be due to a thin delicate membrane which extended completely across the lumen of the bowel at this point.

In a review of the literature no mention of this particular type of congenital obstructive lesion was found. Roentgenograms and photographs of postmortem specimen are included.

LESTER W. PAUL, M.D.

THE LIVER

Calcified Hydatid Cysts of the Liver in the Roentgenogram. Alina Kowalska-Smigielska. Polski Przegl. Radiol., **13**, 139–144, 1938.

The author presents the case of a 43-year-old patient suffering from attacks of pain in the right epigastrium accompanied by fever and icterus. The roentgenogram showed numerous rounded calcifications in the liver region. The liver itself was enlarged.

The assumption of echinococcus disease was confirmed by the history of the case and the positive cutireaction.

ERNST A. SCHMIDT, M.D.

The Clinical and Roentgenological Diagnosis of Echinococcus Alveolaris of the Liver. B. Steinmann. Schweiz. med. Wchnschr., **68**, 1411–1415, Dec. 31, 1938.

The author reports, in detail, a case of echinococcus alveolaris of the liver, complicated by pulmonary tuberculosis, in which the diagnosis was manifested by hepatic calcifications observed roentgenologically. He believes this diagnosis could be made more frequently if a roentgenologic study, with this in mind, and antigenic reactions are used. The diagnosis must be considered when the clinical picture suggests primary or metastatic liver carcinoma, but there is no tumor; or when no cause can be found for a severe icterus. Other causes of hepatic calcification are said to be very rare. The article presents a brief discussion of

the geographic distribution of this disease in Switzerland and the neighboring portions of France and Germany.

LEWIS G. JACOBS, M.D.

Liver Abscesses: Report of Three Cases. W. Francis Martin. South. Med. and Surg., 101, 66-68, February, 1939.

About 75 per cent of liver abscesses are amebic and the remaining 25 per cent are pyogenic. Both may occur solitary or multiple. The author discusses the symptoms, diagnosis, and treatment, and reports three cases. Roentgen examination in one case revealed elevation and immobility of the diaphragm and some signs of rupture into the lung, and, in another case, showed enlargement of the liver and a defect in the transverse colon, suggestive of amebic infection.

L. W. PAUL, M.D.

THE LUNGS

Pulmonary Tomography: Inadequacy of Radiography. Camino. Bull. et mém. Soc. de radiol. méd. de France, 26, 392-395, June, 1938.

A series of tomographs of the chest are presented to demonstrate the value of this method in showing lesions not visualized by ordinary radiographic technics.

S. R. BEATTY, M.D.

Miliary Lesions of the Lung, Roentgenographically Considered. Ray A. Carter. California and West. Med., 50, 94-98, February, 1939.

The author describes many different conditions which may produce miliary lesions in the lungs, which are demonstrable on the x-ray film. He believes that the miliary appearance is most frequently due to tuberculous or nodular silicosis, and occasionally, miliary carcinomatosis, and that there are many other causes which cannot be differentiated by x-ray examination without a thorough history and study of the clinical and laboratory findings.

JAMES J. CLARK, M.D.

Result of the Radiologic Survey of the Schools of Charleville. Blairon. Bull. et mém. Soc. de radiol. méd. de France, 26, 551-559, October, 1938.

A radioscopic survey of 3,000 children of the schools of Charleville (France) made possible the demonstration of some type of pathology in 52 per cent. There was some type of involvement of the lung or pleura in 2 per cent, 30 per cent had enlargement of the hilar shadows, 8 per cent had abnormalities of the spine, and in 12 per cent there was some abnormality of the cardiac shadow.

Blairon urges the necessity of a program of yearly fluoroscopic study of all students of the public schools of France. He believes that fluoroscopy is an adequate means of diagnosis when practised by radiologists of at least five years' experience. Examinations can be made rapidly, only four or five seconds sufficing in most cases, and the children need not be undressed. While fluoroscopy is admittedly less desirable than radiography, it is much better than physical examination alone, but should be used as a complement to clinical studies. The expense of radiography is prohibitive.

The comments of the other members of the Society are interesting. Radioscopy is inadequate from the diagnostic standpoint, particularly when such large numbers of children are to be examined in rapid succession, as inaccuracies are bound to occur with visual fatigue. The clothing should by all means be removed. There are few radiologists of sufficient experience relative to the number of examinations that would be made, and it is quite certain that these men would be the last ones considered to conduct such a survey.

S. R. BEATTY, M.D.

The Place of Serioscopy in the Practice of Phthisiology. Bonte and Warembourg. Bull. et mém. Soc. de radiol. méd. de France, 26, 401, 402, June, 1938.

The authors find serioscopy an invaluable aid in the study of the thorax. Lesions otherwise unseen can be demonstrated and accurate localization made possible.

S. R. BEATTY, M.D.

PHYSICS OF RADIATION

A Determination of e/m from the Refraction of X-ray in a Diamond Prism. J. A. Bearden. Phys. Rev., 54, 698-704, Nov. 1, 1938.

The ratio of the electric charge on an electron to its mass is, of course, one of the fundamental physical constants. There are many ways of determining this constant. The present paper describes an experimental determination by observing the amount of refraction of x-ray (the copper K_β line) in a diamond prism. The author comes out with good agreement with other measurements of the constant.

This is interesting to a radiologist because of the actual use of refraction of x-ray, which is, of course, a very small effect indeed. It is also interesting because the use of a polished diamond prism had proved sufficiently exciting so that descriptions of the experiments have appeared in the daily papers.

R. R. NEWELL, M.D.

The Paths of Ions in the Cyclotron. L. H. Thomas. Phys. Rev., 54, 580-598, Oct. 15, 1938.

This article concerns the question of the limitation of energy which can be given to an ion accelerated in the cyclotron, because as it gets to extremely high speed the relativity effect of apparent increase in mass upsets the balance required for proper focusing. Thomas shows how it is possible to escape from this limitation by making the magnetic field radially asymmetrical, that is, making it vary with the polar angle.

R. R. NEWELL, M.D.

RADIATION

Geometrical Factors in the Measurement of Radiation in Roentgens. C. C. Lauritsen. British Jour. Radiol., **11**, 471–478, July, 1938.

There are two ambiguities in the definition of the roentgen: (1) the definition does not state whether scattered radiation shall or shall not be included in the measurement, and (2) the definition is based on the ionization produced per c.c. of air. It is customary and convenient to measure instead the ionization produced in an unknown volume by the electrons originating per c.c. of air at a certain point, which is a different thing.

If radiation has long wave length, or the medium used is solid, the electrons produced during radiation have a short path, and ionization may be regarded as taking place at the point where the energy of radiation is converted into the kinetic energy of the electron. This is not true with short length radiation, or if the medium is air, as many of the ions will be produced a long way from the point of conversion of energy of radiation. In special cases in air, the ions which escape from a given volume will be exactly equaled by those reaching that volume but produced elsewhere. When this happens, compensation has taken place, but this is not usually the case. A wide beam of parallel radiation will give compensation, but it is complicated by the presence of scattered radiation. The measurement of ionization in a wide beam, does not, therefore, give a unique determination of the intensity at the source.

In a narrow beam, such as is commonly used with an open chamber, compensation is far from complete, so that we do not measure the number of ions produced in a known volume in the beam, but rather the ionization produced in an unknown volume in and around the beam, produced by electrons equivalent in number and energy to those ejected in a known volume in the beam. It is usually agreed that this procedure is appropriate for the measurement of quantity of radiation in roentgens, and usage has established the roentgen on these terms, rather than those of the definition.

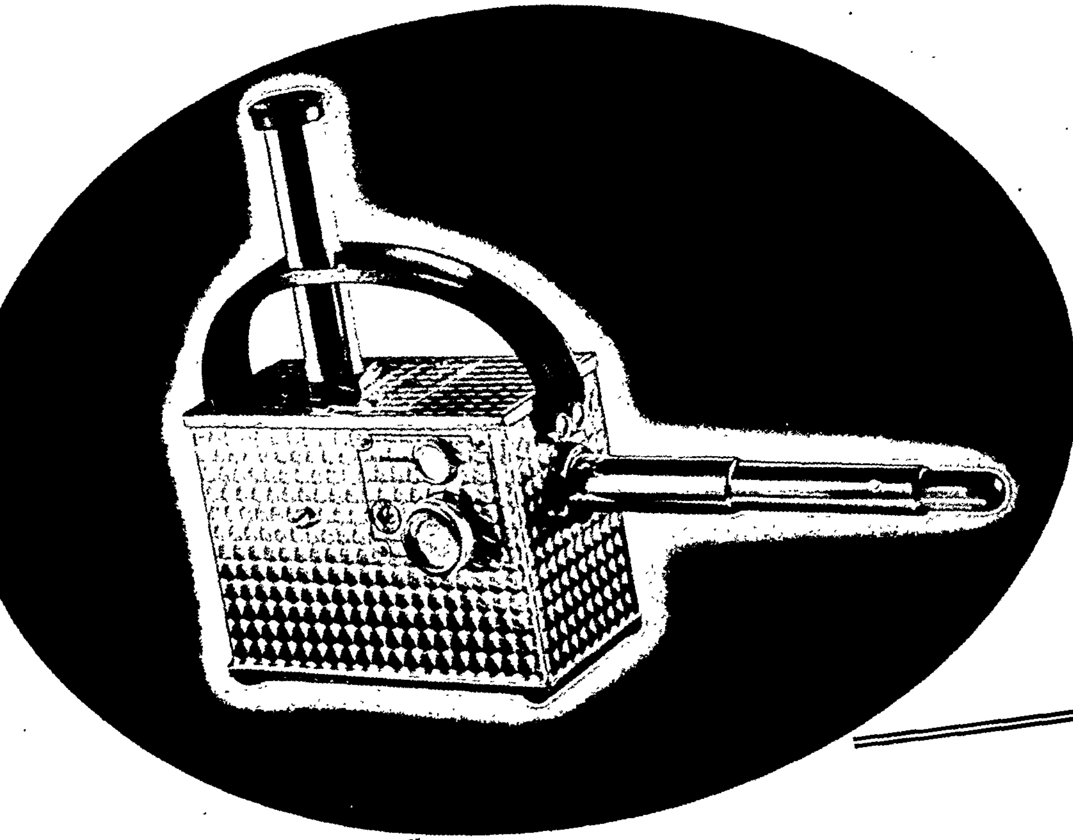
If radiation from a point source is to be measured, as from a small quantity of radium, it is evident that it is more convenient to define the roentgen in terms of energy converted, rather than in terms of ionization. If we consider spherical shells of air of equal thickness surrounding the source, it is obvious that the primary energy converted into kinetic energy is the same for all shells, but the ionization per shell varies in a complicated manner with the distance. So, if the roentgen is defined in terms of energy converted, then intensity is simply inversely proportional to the square of the distance. The operation of this principle is illustrated mathematically.

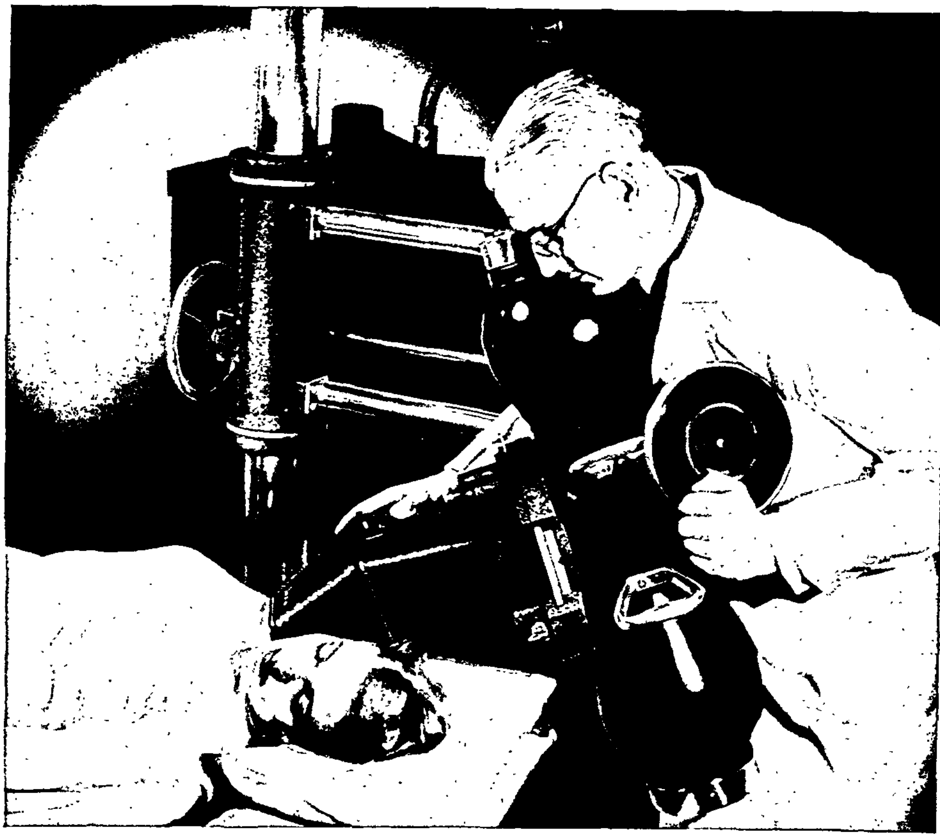
S. J. Hawley, M.D.

Physical Measurements in High Voltage X-ray Therapy. Ralph Phillips and G. S. Innes. British Jour. Radiol., **11**, 498–503, July, 1938.

Physical aspects of x-rays produced at 700 kv. are reported. The authors consider the voltage correct within plus or minus 1 per cent. At 100 cm. distance the intensity in free air is 13 r per minute per milliampere. Absorption curves for iron, copper, tin, lead, and a compound filter of lead, tin, copper, and aluminium are given. Half and quarter value layers in copper, tin, and wax are given. Curves showing variation of percentage back-scatter at the surface with voltage from 200 to 700 kv. are given and also variation of back-scatter with focal skin distance and field area. An isodose curve for a 10 × 10 cm. field at 60 cm. S.T.D. is given. Curves showing variations of percentage depth dose at 10 cm. with field area, focal skin distance, filtration, and voltage are given.

S. J. Hawley, M.D.





NEXT ANNUAL MEETING, ATLANTA-BILTMORE HOTEL, ATLANTA, GEORGIA, DEC. 11–15, 1939

RADIOLOGY

A MONTHLY JOURNAL DEVOTED TO CLINICAL RADIOLOGY AND ALLIED SCIENCES

SEPTEMBER · 1939

VOLUME 33 NUMBER 3

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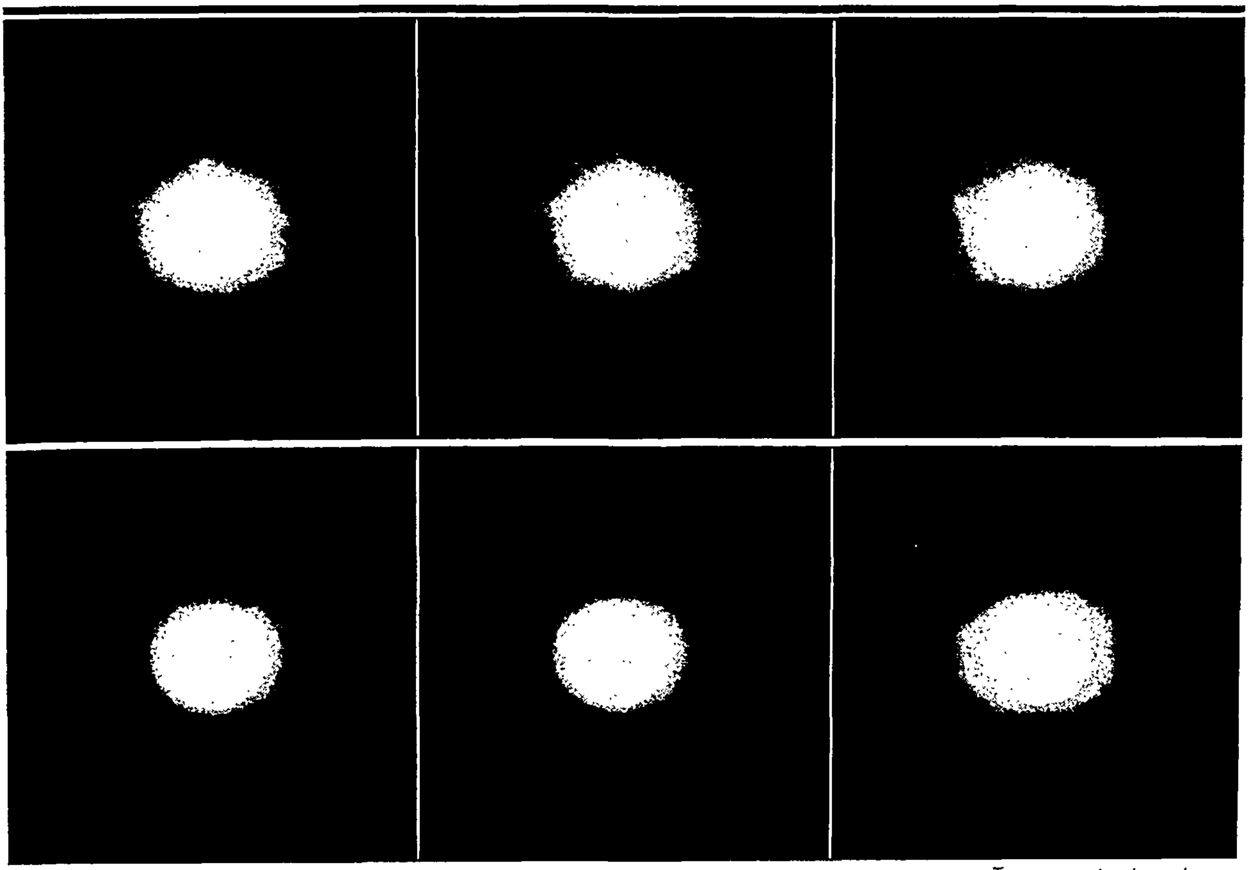

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THE ROENTGENOLOGIC DIAGNOSIS OF PNEUMOCONIOSIS (SILICOSIS) AND USE OF THE "ELECTRIC EYE" TO DETERMINE REGIONAL DENSITIES[1]

By LEWIS GREGORY COLE, M.D., Director of Silicotic Research, John B. Piérce Foundation, *and* WILLIAM GREGORY COLE, M.D., *New York City*

FOREWORD

SUCH a survey of this subject as we have been able to make indicates that cases diagnosed as silicosis differ in various communities and even in various industries in the same community. We believe, therefore, that a comprehensive approach to this problem should be based on a study of roentgenologic and pathologic findings observed in various industries and widely separated communities. To those who have aided us in the assembling of this material we wish to give special credit, and to express our sincere appreciation. The list is too long for us to include them as collaborators, but we do wish to mention at the very beginning that without the co-operation of the following men this investigation could not have been completed.

Harvey C. Bridgers, M.D., Blue Ridge Summit, Pa.
Philip Howard Cook, M.D., Worcester, Mass.
William Joseph Corcoran, M.D., Scranton, Pa.
Sol Davidson, M.D., Rochester, N. Y.
John S. Derr, M.D., Frederick, Md.
C. Zent Garber, M.D., New York, N. Y.
Leroy Gardner, M.D., Saranac Lake, N. Y.
Arial W. George, M.D., Boston, Mass.
Omer Grenville Hague, M.D., Winnipeg, Man., Canada.
Leonidas B. Harless, M.D., Gauley Bridge, W. Va.
Courtenay I. Headland, M.D., Yonkers, N. Y.
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James E. McArthur, M.D., Noranda, Quebec, Canada.
Eugene P. Pendergrass, M.D., Philadelphia, Pa.
Raphael Pomeranz, M.D., Newark, N. J.
Robert E. Pound, M.D., New York, N. Y.
Benjamin S. Putts, M.D., Erie, Pa.
Walter A. Schmitz, M.D., Middletown, N. Y.
Israel Steinberg, M.D., New York, N. Y.
Beverly L. Vosburgh, M.D., Schenectady, N. Y.

Importance of the Roentgenologic Diagnosis of Pneumoconiosis (Silicosis).—It is almost universally conceded that the diagnosis of pneumoconiosis (silicosis) depends upon the accurate interpretation of satis-

[1] This is one of a series of papers contributed by friends and former pupils of I. Seth Hirsch, M.D.

factory roentgenograms, preferably stereoscopic ones. The British, in South Africa, early recognized this, and that America

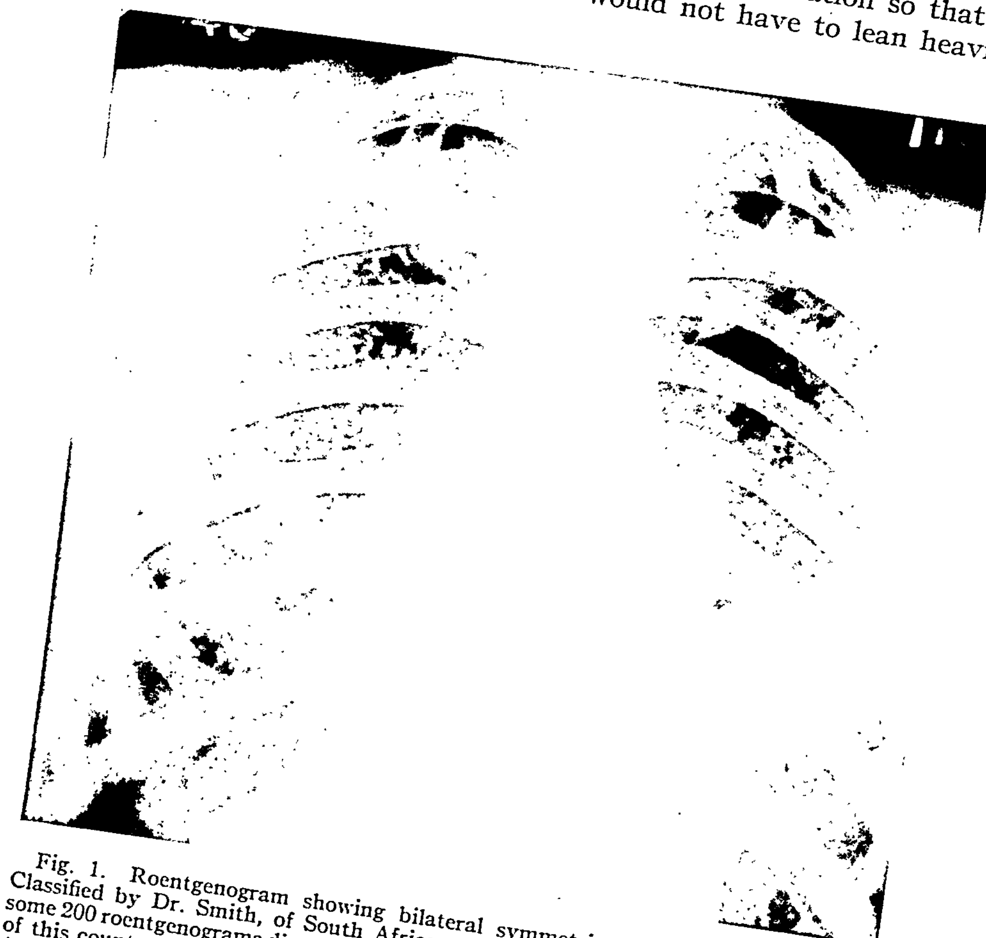

Fig. 1. Roentgenogram showing bilateral symmetrical mottling (nodulation). Classified by Dr. Smith, of South Africa, as "primary." This film is classical of some 200 roentgenograms diagnosed as silicosis by roentgenologists in various sections of this country and Canada, and now registered with the J. B. Pierce Foundation. (*Lent by Dr. McArthur, Noranda, Quebec.*)

The vast majority of these roentgenograms can be diagnosed as pneumoconiosis as rapidly as they can be placed upon the light box. Cases less extensive than this were classified by Dr. Smith as "ante-primary," and cases less extensive than the "ante-primary" ones were classified as "MFU++" or "MFU+." More extensive cases were classified as "secondary," and the terminal stage was classified as "infected," either tuberculous or non-tuberculous.

agreed with the British was manifested by a report made to the United States Government (1) by a committee of physicians, in which it was stated that "only the physician who has examined the subject, has obtained the occupational history of adequate exposure to silica dust, and has before him a suitable roentgenogram of the chest should make the diagnosis of silicosis."

In a later paragraph, the committee making the report stated that it was their purpose to devise some method or standard of interpretation so that the clinician would not have to lean heavily on an experienced roentgenologist for the diagnosis of silicosis. But the diagnosis of pneumoconiosis (silicosis) is not unlike the detection of a criminal. In some cases the evidence is so simple that the criminal can be discovered by the merest tyro of a detective, while in other cases, only the most elaborate correlation of seemingly unimportant findings enables the G-men to apprehend the criminal. We believe that the elimination of an x-ray specialist in the diagnosis of pneumoconiosis (silicosis) has

led to unfairness both to the laborer and the industry in which he labors, and that a more elaborate effort to correlate roentgenologic and pathologic findings is imperative, if individuals and companies are to be treated fairly.

Roentgenograms of the lungs of subjects who have inhaled quantities of certain mineral dusts over long periods of time show findings that are not observed in roentgenograms of those not so exposed. This fact is clearly demonstrated by comparing roentgenograms of groups of subjects in dust-hazard industries with roentgenograms of groups of banking clerks.

The lungs of those exposed to certain mineral dusts show morbid changes in the form of deposits of tissue composed mostly of collagen, though they may also contain dust-laden phagocytes, desquamated cells from the lining membrane of the alveoli, disintegrated white blood cells, and débris within the alveoli. The amount of morbid tissue may be so slight that it is not discernible to the naked eye, and even so slight as to be overlooked upon microscopic examination. On the other hand, the amount may be so great as to practically fill the thoracic cage.

Dust-laden air is inhaled and the larger dust particles are expectorated because of the action of the cilia, but the smaller particles find their way to the alveoli and are mopped up by the phagocytes. The distribution of the morbid tissue, therefore, whether slight or extensive, is bilateral and relatively symmetrical. Much of it is laid down along anatomic structures, especially in the early stage of the process, but nodules, or spherical whorls of collagen, which are the most familiar type of morbid change, do not conform to anatomic structures.

Even slight deposits of morbid tissue, scattered discretely through both lungs, cause increased density of the lungs which is readily discernible on the roentgenogram (Figs. 1 and 18) when one's eye is trained to see it or the standard photometer or "electric eye" is employed to record it. Massive deposits of morbid tissue are so large and dense that their shadows on the roentgenogram may obscure the outline of the heart or even obscure the ribs. Morbid deposits in the lung occupy space that would otherwise be filled with air, and, therefore, cast shadows on the roentgenogram. Such shadows, referred to as "roentgenologic findings," correspond in size, shape, and distribution to deposits of morbid tissue in the lung.

Roentgenologic findings may be considered under two primary groups: (*A*) structural changes which cause a characteristic pattern on the roentgenogram; (*B*) regional distribution of densities on the roentgenogram, regardless of their pattern. We shall consider first the pattern approach.

A.—PATTERN APPROACH

Morbid tissue deposits in pneumoconiotic (silicotic) lungs fall into four main patterns, illustrated by the schematic drawings in Figures 2, 3, 4, and 5. Roentgenologic shadows resulting from and corresponding to these four patterns of morbid tissue deposits are illustrated in Figures 6, 7, 8, and 9. Although different dust irritants may be responsible for these four patterns, two or more of these findings are often seen in the same roentgenogram. Since they are more readily described and comprehended when considered separately, we shall take them up as follows:

1. Accentuated hilar and linear markings.
2. Nodules—small white spots on a dark background.
3. Pockmarks—small dark spots surrounded by light rings.
4. A general nondescript haze, or cloudiness.

1. *Accentuated Hilar and Linear Markings of Pneumoconiosis (Silicosis).*—The term "accentuated hilar and linear markings" is applied to a group of roentgenologic findings observed by Pancoast and described by him as constituting "the perivascular–peribronchial–lymph-node manifestation of pneumoconiosis."

The root or hilus of the lung is composed of a pulmonary artery and vein, the right

and left bronchus and its immediate branches, lymphatic glands and structures, and the stroma supporting these structures. In roentgenograms of normal lungs, these structures are fairly clear-cut, and usually the blood vessels and bronchi can be readily identified. They cast a definite shadow compared with the well-ventilated lung in the peripheral third.

For the sake of convenience in studying the accentuated linear and hilar markings of pneumoconiotic (silicotic) lungs, we have divided the lung into three regions: (1) the central or hilar region; (2) the middle third; (3) the outer or peripheral third.

Roentgenograms of subjects exposed to relatively small amounts of certain mineral dusts often manifest a definite increase in the density and size of the hilar shadow. Increased density in the central or hilar region is due to a deposit of morbid tissue composed of phagocytes laden with mineral dust, and collagen laid down in the stroma of the lymphatic glands and structures adjacent to them. Hilar shadows on the roentgenogram may be clear-cut, and, in such cases, are interpreted as enlarged, circumscribed glands. On the other hand, hilar shadows on the roentgenogram may extend out along the branches of the large blood vessels and bronchi. These extensions or prolonged shadows are caused by phagocytes laden with mineral dust which have been dammed back or caught in a traffic jam on their progress to the hilus (Fig. 10-*A*), or due to envelopes of collagen around the larger blood vessels and bronchi (Fig. 10-*B*), or to a proliferation of fixed cells in these regions. When shadows of these prolongations are well defined on the roentgenogram, they project out into the lung along the anatomic structures of the blood vessels and bronchi.

Some subjects, exposed to essentially the same type and amount of exposure as those manifesting increased hilar markings, develop accentuated linear markings in the middle third of the lung. Here the markings run parallel to the medium-sized bronchi and blood vessels. They are shadows of morbid tissue laid down in the peribronchial and perivascular structures. This morbid tissue is caused by dust-laden phagocytes and a proliferation of fixed cells in the interstitial structures.

Accentuated linear markings may also occur in the peripheral third of the lung, and here their roentgenologic appearance is fine and lacy, in comparison with accentuated markings in the middle third. Accentuated markings in the peripheral third are caused by small deposits of collagen along terminal blood vessels and bronchi. Increased linear markings in this region often cause a general mottling which in the past has not been differentiated from fine nodulation and pockmarking, but when films are studied with these fine linear markings in mind, they can be differentiated readily from the other three roentgenologic patterns of pneumoconiosis (silicosis).

The migrating phagocytes are an important factor in the morbid changes which cause increased hilar and linear markings. They may be loaded with silica (non-opaque refracting crystals), or they may be loaded with other foreign-body flecks (opaque, non-refracting crystals), but in either event they are a contributing cause to the accentuated hilar and linear markings.

2. *Nodules—Small White Spots on a Dark Background.*—Roentgenograms of subjects exposed to dust hazards often exhibit small white spots on a black background which are referred to as "nodules." These small white discs were early recognized by the investigators of pneumoconiosis in South Africa, and were named "nodules" by them. Nodules may be fine or coarse. They are dense, clear-cut shadows of morbid tissue deposited in the parenchyma of the lung. They are bilateral and relatively symmetrical and more marked in the mid-lung fields.

The morbid tissue which forms the nodule is spherical, with a well-defined circumference. It is composed of layers of collagen laid down upon one another in whorls, much like the layers of an onion. A microscopic section of such a nodule

reminds one of the whorls in a finger print (Fig. 11-*A*). Two, three, four, or even five of these individual nodules may be connected by strands of collagen so that they form a conglomerate nodule (Fig. 11-*B*). On the roentgenogram, the shadows of the individual nodules are very small. The conglomerate ones are larger, but are observed to be composed of two or more isolated nodules, connected by collagen fibrils. (Whether the small nodules increase in size and eventually become the large, discrete nodule, or whether a group of small nodules coalesce and form one of the large nodules is problematical and does not come within the scope of this communication, but will be considered in another article devoted to the development of collagen in silicosis.)

Nodules vary in size in different patients and even in the same patient. The variation in size observed in different patients may be influenced by the character of the dust irritant in different industries. Individual discs may be so small as to be scarcely discernible to the naked eye, or as large as a grain of wheat. The larger ones are referred to as "coarse nodulation" and the smaller ones as "fine nodulation." The larger discs are extremely brilliant because of the solidity of the nodule, and they cause a symmetrical mottling of both lung-fields. On the roentgenogram, these appear to be closer together and far more numerous than they are observed to be on a cut section, for on a cut section one sees only the nodules that appear in one plane, whereas on the roentgenogram the shadows of all the nodules are recorded and appear on the flat surface of the film. This accounts for a remark frequently made by the pathologist to the effect that there are not nearly so many nodules as are shown on the roentgenogram.

Heretofore, the nodule has been considered pathognomonic of silicosis, and is the finding on which the definition is based. However, nodules such as shown in Figure 11-*A* are observed to contain only a few foreign-body flecks and the majority of these are opaque, non-refracting flecks (therefore, not silica). In our opinion, the nodule is pathognomonic of pneumoconiosis, not silicosis.

3. *Pockmarks—Small Dark Spots Surrounded by a Light Ring.*—Roentgenograms of subjects exposed to certain mineral dusts may show small dark spots surrounded by white rings, somewhat irregular in shape. This finding, which we have termed "pockmarking," has, for some reason, been overlooked in the past or confused with the mottling due to nodulation or peribronchial accentuation in the peripheral regions of the lung. This finding reminds one of the full-blown stage of chickenpox or smallpox, and we have, therefore, designated it as the "pocking" sign or "pockmarking."

On the roentgenogram, numerous small areas of diminished density cause black spots about one-eighth inch in diameter, and these are surrounded by circular areas of increased density. They are the direct reverse of the nodule, being black, in contradistinction to the white discs or nodules. Pockmarks are bilateral and relatively uniform in distribution, though more marked in the peripheral third of the lung. They may be more advanced on one side than the other.

It is difficult to account for pockmarks by recognized morbid changes (Fig. 12), but they are best understood by an intensive study of the markings in roentgenograms of normal lungs. In a well-timed roentgenogram of a normal lung, one can see the fish-net appearance in the periphery created by terminal blood vessels as they form their anastomosing loops from arteries to veins. These multiple small loops form the septa between terminal lobules of the lung. Such lobules can be noted on the surface of a removed lung when it is gradually inflated, many deflated lobules popping up as air is forced into them. This network of anastomosing veins and arteries is the anatomic, architectural pattern on which the pockmarks develop (Fig. 14). With the deposition of fine fibrils of collagen in the interstitial structures in pneumoconiosis (silicosis), the

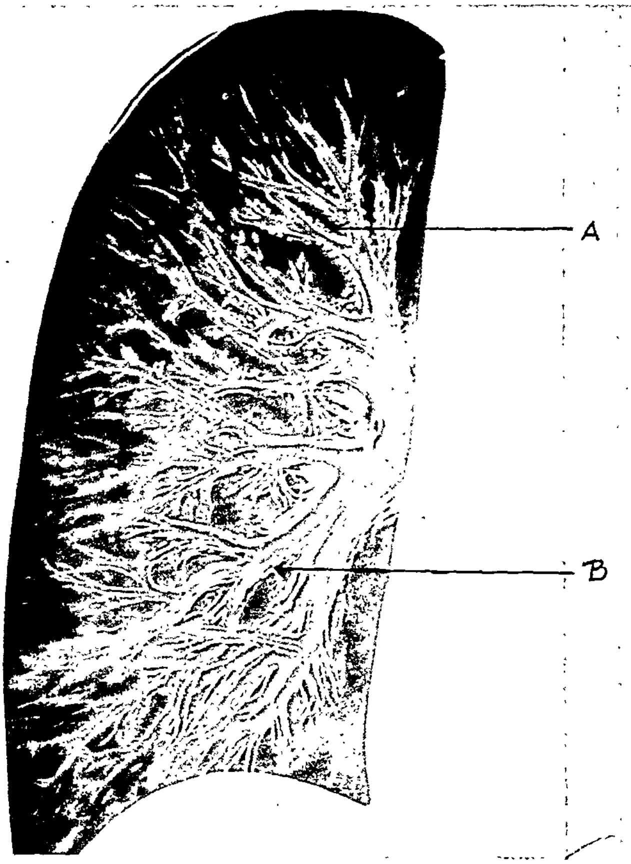

Fig. 2.

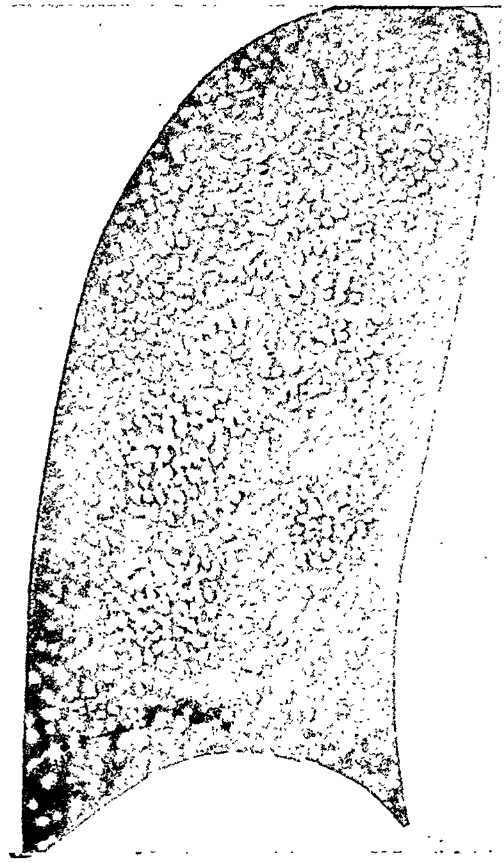

Fig. 3.

Fig. 2. Perivascular–peribronchial–lymph-node manifestation of pneumoconiosis (Pancoast's disease). A schematic drawing presenting the author's conception of the combined roentgenologic and pathologic findings of this type of disease.

Accentuated hilar and linear markings are due to two pathologic findings—foreign-body flecks, and collagen deposits. Circles (*A*) indicate phagocytes which have clumped together foreign-body flecks that are opaque to both light and x-ray. Dashes (*B*) indicate collagen deposits laid down in the form of whorls or as laminæ around the blood vessels and bronchi. Both *A* and *B* accentuate the linear markings.

Although accentuated linear markings are a definite manifestation of pneumoconiosis, the lesion is of little or no clinical significance in early or even moderately advanced stages. The subject usually lives to a ripe old age without suspecting he has a lesion in the lungs.

Socially and economically, this type of lesion is a menace to both labor and industry. A patient who is perfectly able to work and wants to work may not be able to get a job because he has such a lesion. On the other hand, industry may be saddled with the compensation of a man with such a lesion who is perfectly able to work but does not want to. Legislatural acts fail to differentiate this type of pneumoconiosis which does not require compensation, from the more serious types of lesions which do deserve compensation at some stage in the life history of the disease.

Fig. 3. Nodular pneumoconiosis is the conventional type on which the diagnosis and even the definition of silicosis are based. Our observations indicate that these nodules, considered pathognomonic of silicosis, are not caused by silica. (Data substantiating this contention will be submitted in a subsequent article.)

Light and dark field examinations of these nodules reveal an overwhelming preponderance of black flecks that are not silica crystals, and only relatively few refractive crystals of silica, therefore, it would seem irrational to consider the few silica crystals as the etiologic factor in the development of these nodules. Nodules are composed of collagen, laid down like the layers of an onion; they are bilateral, symmetrical, and separated from one another by ventilated lung. Later they may grow together in round masses in the mid-lung field, resembling a pawnbroker's sign. Roentgenologically, they appear as white spots on a black background. The lungs may be literally shot full of these nodules without the patient having dyspnea or any other symptoms, and these patients, too, may live to a ripe old age, without knowing that they have nodular pneumoconiosis.

Socially and economically, such subjects are able to carry on hard labor at the prevailing wage. Should they be prevented from getting such jobs? Or lose the ones they have? Legislative acts are built primarily around this type of lesion, which has been considered silicosis.

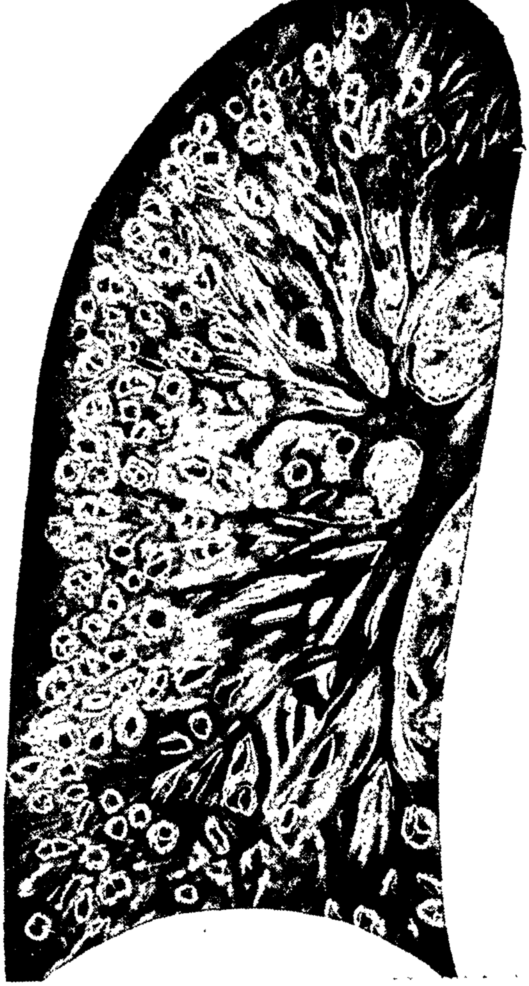

Fig. 4.

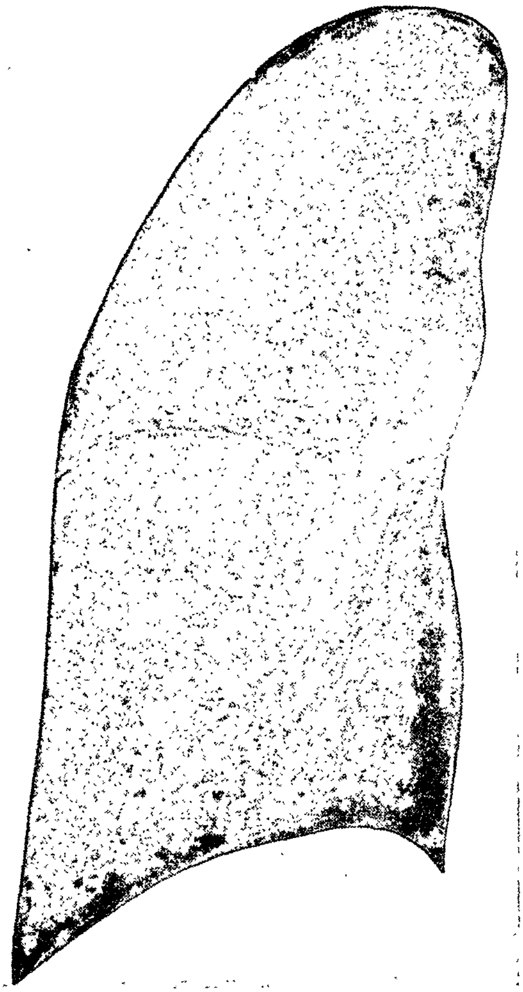

Fig. 5.

Fig. 4. Pockmarking is the roentgenologic manifestation of a pathologic finding that has not been hitherto recognized, or which, at least, has not been differentiated from the other three types of pneumoconiosis.

Roentgenologically, pockmarking is evidenced by small black spots on a white background or surrounded by white rings. These black spots are caused by air cysts in the lung which are surrounded by lung rendered relatively dense from collagen laid down in the form of whorls or strands. The air cysts correspond anatomically with terminal lobes that are choked off from the bronchioles by the ball-valve action of the collagen laid down around the smaller bronchi.

In a microscopic section in which these air cysts are most marked, the opaque, non-refractive foreign-body flecks overwhelmingly predominate the transparent or translucent refractive silica crystals.

Air cysts are of more clinical significance than the nodules and are more likely to be associated with dyspnea and other symptoms. They *should not*, however, be used as the only criterion to determine whether or not the subject is incapacitated for work. Since these air cysts and the pockmarking which they cause have not been recognized before, they have played no part in legislatural acts. We believe, however, that in the future the presence of these air cysts in relatively dense lungs may play an important part in determining when compensation should begin.

Fig. 5. Rapidly developing or acute silicosis is evidenced roentgenologically by a general haze or diffuse cloudiness which obscures the normal markings of the lungs.

The perivascular and peribronchial deposits of dust-laden phagocytes and laminæ of collagen, and the nodular whorls and areas of massive collagenization are absent or extremely scanty in this type of disease, even in the terminal stage.

The general haze and diffuse cloudiness observed in the roentgenograms are caused by an incomplete filling or consolidation of the alveoli and air passages with phagocytes, and hypertrophied and proliferated cells, and also by a thickening of the walls of the alveoli themselves.

Economically and socially, these subjects present a most serious problem. They deserve adequate compensation as soon as the diagnosis is definitely established, or certainly as soon as dyspnea develops, which is relatively early. Injustices have been done in the past because subjects having this type of lesion were unfortunate in that they did not have the well-developed nodulation on which the diagnosis and definition of the disease are based. Since roentgenograms showed no nodulation, there was a tendency to consider that such cases were not silicosis and, *therefore*, were *not* "*within the law.*"

normal network described becomes more coarse. It is the shadow of this increased collagen, laid like an envelope around terminal blood vessels and bronchi (Fig. 15), which causes the pockmarking on the roentgenogram (Fig. 8). When the pockmarks are superimposed over the drawing of the anatomic structures, the pathogenesis of the pockmark becomes startlingly evident (Fig. 4).

Pockmarks are sometimes observed also in the central or hilar portion of the lung, and there they are definitely established to be bronchi viewed on end, surrounded by a laminated layer or envelope of collagen.

As pneumoconiosis (silicosis) progresses, pockmarks may be obscured, just as the individual whorls or nodules are obscured by conglomerate nodules or massive collagenization. The mottling caused by the pockmarks is increased in density by a laying down of collagen until the center of the pockmark is not evident and the mass becomes a relatively solid area.

4. *General Haze or Cloudiness.*—Acute silicosis is manifested roentgenologically by a general haze or cloudiness which tends to obscure the normal markings. The findings are difficult to describe; there is a general cloudiness of the entire lung-fields. In localized areas, this general haze has developed into definite clouds, so that the appearance is not unlike a view from an airplane when we are looking down on white clouds and through the breaks in the clouds we see darker, less misty areas. The ventilation of the lung is materially diminished, and yet there seems to be no characteristic pattern observed on the roentgenogram. The accentuated hilar and linear markings, the nodules, and pockmarks are absent, or obscured by the lesion which causes the haze.

The general haze is caused by a variety of morbid changes (Figs. 13-*A* and 13-*B*): (1) thickening of the walls of the alveoli; (2) deposits of various types of material within the alveoli; (3) envelopes of collagen surrounding the smaller blood vessels and bronchi. Viewed microscopically, one observes envelopes of collagen around the larger and medium-sized blood vessels, and a few single or conglomerate whorls scattered through the lung, but these latter findings are usually slight and are obscured by the general cloudiness characteristic of the disease.

The first cause contributing to the general haze is the thickening of the walls of the alveoli. These may be thickened to eight or ten times their normal size, and their abnormal thickness is due to a laying down of collagen in certain localized regions, and an immense dilatation and engorgement of the capillary network forming the alveolar walls in other regions. In the regions in which the alveolar walls are thickened by collagen, the collagen has so constricted the capillaries that red blood cells are absent, and microscopic field after field may be studied without observing a single one. These are avascular areas. In other regions of the lung the alveolar walls are thickened to an equal degree by an immense dilatation and engorgement of the capillary network which forms them. These are hypervascular areas. There is a minimal amount of collagen in the walls of the alveoli, but there may be a seepage of the blood cells into the alveoli. The walls of the alveoli, thickened in these two manners, encroach upon the alveoli and diminish the ventilation of the lung, thereby contributing to the general haze.

A second contributing cause is the deposit of various types of material within the alveoli. Phagocytes, either empty or silica-laden, are deposited in large numbers in the alveoli. Cells of the membrane lining the alveolar walls are hypertrophied, proliferated, and may be desquamated into an alveolus. The alveoli may also contain an amorphous material in combination with the "cholesterol crystal clefts" described by Gardner (6).

A third cause contributing to the general haze is an envelope of collagen encircling the smaller blood vessels and bronchi.

All of these factors tend to diminish the ventilation of the lung and increase its solidity, but the lung still retains an amount

of ventilation, so that the solidity gives only a general haze rather than a dense shadow such as that caused by consolidation or interstitial collagenization of the nodular type.[2]

The general haze is bilateral and relatively uniform in its distribution. Poorly defined areas of increased density of the lung vary in size and are evenly distributed throughout both lungs. The absence of accentuated hilar and linear markings, of nodules, and of pockmarks often cause the roentgenologist to overlook the general haze, unless he is silica-minded, and even then he is apt to disregard the finding unless he is familiar with the morbid changes of acute silicosis. The general haze is a finding rarely observed in any other lesion. We believe that the roentgenologic problem of acute silicosis is its recognition in unsuspected cases, rather than its differentiation after the lesion is once recognized.

The reader may note that in discussing the manifestations above we have not hesitated to use the term "silicosis." This is because microscopic sections of such lungs show an overwhelming amount of silica (non-opaque refracting crystals) and relatively few foreign-body flecks of other elements. An analysis of lungs showing roentgenologic nodulation revealed that they contained an overwhelming preponderance of opaque non-refracting crystals, and when referring to them we use the term "pneumoconiosis (silicosis)."

Massive Collagenization.—Thus far we have analyzed four roentgenologic findings with their corresponding pathologic findings. We have discussed and illustrated the four patterns in cases of pneumoconiosis (silicosis) in which the disease had progressed sufficiently for the pattern to be well marked but had not developed to such a degree that the pattern was obscured on the roentgenogram. Often three or even four of the roentgenologic manifestations described may be observed on the same roentgenogram, but one pattern usually predominates so that the case is readily classified.

As pneumoconiosis (silicosis) progresses, the morbid tissue is increased by massive deposits of collagen. These cast dense roentgenologic shadows which obscure the nodulation and pockmarking observed in earlier stages of the disease. The collagen masses may be made up of large numbers of nodules closely packed together (Fig. 7), or of strands of collagen so closely packed as to obliterate the pattern (Fig. 19).

Massive collagenization may develop in three regions of the lung:

(1) Mid-lung Field. A "pawnbroker's sign" may be formed by three clumps or masses of collagen deposited in the right mid-lung field where the lobes of the lung join each other (Figs. 7 and 8). They are arranged one above and two below, and thus give the appearance of a pawnbroker's sign. Perhaps the anatomic structures formed by the three lobes of the lung account for these dense masses. When dense masses of collagen form on the left side, one of the masses or balls of the "pawnbroker's sign" is usually absent.

(2) Pleura. Massive deposits of collagen may develop in the pleura at the *apex of the lower lobe* (Fig. 17). There they form a mass with a clear-cut upper surface that arches outward and downward from a region near the spine, opposite the head of the fourth rib. Seen on the roentgenogram, the upper surface of this shadow is well defined and reminds one of the dome of the diaphragm. The under surface of this arch is irregular and fades into the mottling of the parenchyma of the lung. (The mottling, of course, is caused by a diffuse deposit of collagen in the parenchyma.)

(3) Upper Lung-fields. Masses of collagen having no characteristic pattern may develop in the upper lung-fields. They vary in size from one to two centimeters, in instances in which only a few nodules have formed into a clump too large to be considered a conglomerate nodule, up to

[2] A more detailed description of the morbid changes which cause the general haze of acute silicosis are described in an article entitled "Dyspnea of Silicosis: What Causes It?" which will be published in an early issue of the *Journal of the American Medical Association.*

determine the amount of light that passes through a negative, so that one may know the length of exposure to be used when making lantern slides or reductions of x-ray films.

In using the photometer for this purpose, it soon became evident that different portions of the chest films which we were reproducing, or of which we were making lantern slides, showed great variations as recorded on the meter. When the photometer was placed where the transmitted light passed through the heart, there was an extremely high reading, somewhere around 600 or 700. As we placed the photometer over various portions of the lung-fields, we were aware of a far greater variation in density than was apparent when one casually looked at the film by transmitted light.

We compared the photometric readings in various portions of pneumoconiotic (silicotic) roentgenograms with readings of normal lungs, tuberculous lungs, and lungs showing other pathologic lesions, and found that they varied from all of these. A specific recording of the findings in the fifty or sixty cases referred to was made. The recorded figures scarcely attracted attention, but when we began to place these figures on a chart and arrange the readings, it became apparent that with a certain arrangement we could obtain a spectacular and illuminating graphing.

Graphing of the Photometric Readings.—The readings of a standard Weston Photometer run from 0 to 1,000. An illuminating box was used and a bulb secured which gave a reading of about 900 without any film interposed, or 600 or 700 through the heart. In the lung-fields where there is an appreciable amount of air or ventilation, the normal structures of the lung obstruct x-rays to a lesser degree than does the heart, and, therefore, the lung-fields appear less dense on the roentgenogram than in the region of the heart. If, as described before, the lung is divided into apex, mid-lung fields, and base, the photometer reading in the mid-lung fields would be higher than at the base or apex. As the heart obstructs more rays than does any other portion, the photometer recording is highest here.

In the normal lung, the base is well ventilated and shows a low reading on the photometer. The mid-lung fields show approximately the same resistance to penetration as the base, being a trifle more or a trifle less dense. At the apex, just below the clavicle, where the lung is smaller and not so thick and the muscles heavier, the density of the plate is greater. To make the reading complete, the photometer reading is made over the mid-line in the region of the trachea. Typical photometric readings of a normal lung would read somewhat as follows: heart—500; base—100; mid-lung field—125; apex—135; trachea—450. The relative variations here show that the ventilation in each region is normal (Fig. 24).

We have simplified this reading by putting a rheostat in circuit, so that the transmitted light can be altered and the light through the heart recorded on the meter as 500, regardless of over- or under-exposure of the roentgenogram. Having one constant factor, the findings are more readily charted and compared.

By charting these figures in the manner illustrated, we obtain a chart somewhat resembling a capital *V*. This is the characteristic chart of the normal lung, with which chart pneumoconiotic (silicotic) lungs should be compared.

Characteristic Graphs of Peribronchial Pneumoconiosis (Silicosis).—Peribronchial pneumoconiosis (silicosis) which is manifested by increased linear markings, bilateral and relatively symmetrical, gives photometric readings which, when graphed, become of great value in showing the regional variations in lung densities in the middle, upper, and lower fields. Throughout this article we have referred to roentgenologic findings in terms of lung densities rather than photographic densities, but we are now dealing with measurements of photographic densities on the roentgenogram, and it must be borne in mind that the areas of greatest lung density are evidenced by diminished density of the

roentgenogram, and, therefore, give higher readings on the photometer.

In typical cases of peribronchial pneumoconiosis (silicosis) with accentuated linear markings, we have readings somewhat as follows: heart—500; right base—40; right lung-field—185; right apex—105; trachea—425; left base—40; left lung-field—200; left apex—100.

If these are placed on a chart, with the regions recorded from left to right and the numbers of the photometer recorded in the vertical column, we obtain the characteristic graph of the pneumoconiotic (silicotic) lung of the peribronchial type. This resembles a capital *W* for one lung, and a double *W* for both lungs (Fig. 25). This graphing becomes spectacular when compared with charts of normal lungs, tuberculous lungs, and lungs manifesting neoplasms.

Normal Lungs (Fig. 24): √ √	Chart resembles a capital *V* with a vertical proximal arm.
Peribronchial Pneumoconiotic Lungs: W W	W. W. (Fig. 25).
Tuberculous Lungs: √‾ W	Chart resembles a square root sign in one lung and a capital *W* in the other.
Neoplastic Lungs: √√	Chart resembles a capital *V* with a vertical distal arm.

We believe that the application of the photometer with the charting suggested would be a convenient way of recording the findings observed in a survey of dust-hazard industries, and that an analysis of such charts would help to differentiate the morbid changes caused by dust irritants in different industries and different sections of the country. It is particularly valuable in differentiating peribronchial pneumoconiosis (silicosis) from other lesions, and since this type of lesion is observed more frequently than the others the photometer is of practical importance. Lastly, such a charting has the advantage of stimulating the roentgenologist to a more careful scrutiny of lung densities.

COMPENSATION

There is no doubt in our mind or in the minds of most observers that moderate deposits of certain mineral dusts cause morbid changes in the lung that can be readily recognized roentgenologically. Whether these changes can be differentiated from changes due to other lesions has been problematical. Miners, buffers, grinders, and employees of some other industries manifest roentgenologic findings not observed in groups of cases not exposed to dust hazards—a pattern of accentuated hilar and linear markings. Very early in his investigation of pneumoconiosis, Pancoast (5) recognized these and discussed their significance as follows:

"Now this appearance of prominent hilum shadows and increased prominence of trunk shadows and linear markings, with or without the faint haze, has in this country at least been designated as the *first stage* of silicosis or pneumoconiosis. There may be some excuse for continuing to call this the first stage, but continued experience with cases of pneumoconiosis developing in various industries has led us to question the wisdom of designating any appearance of pneumoconiosis by any term denoting numerical stages of progress. In this particular instance under discussion, the individual may develop the appearance in a comparatively short period of from one to five years, or not pass beyond it, on the other hand, in fifty years. Moreover, it is not apt to be distinguishable as a stage of the past in the more progressive periods of the condition, and in some industries it may be insignificant or indistinguishable as a stage at all. We prefer to designate the appearance by a term which implies its pathological nature and to call it not a stage but the *perivascular-peribronchial-lymph-node type* or preponderance of the condition.

"The appearance of this type, or preponderance, or stage is by no means characteristic of pneumoconiosis but is found as a result of many other conditions, such as acute bronchitis, chronic bronchial catarrh, bronchiectasis, passive congestion from cardiac decompensation, the infiltrating type of malignancy, and polycythemia. It should not be accepted as an evidence of pneumoconiosis, especially in

tion until the roentgenologic nodulation had progressed into massive collagenization, and most of them did not complain until a gross inflammatory or tuberculous lesion was ingrafted.

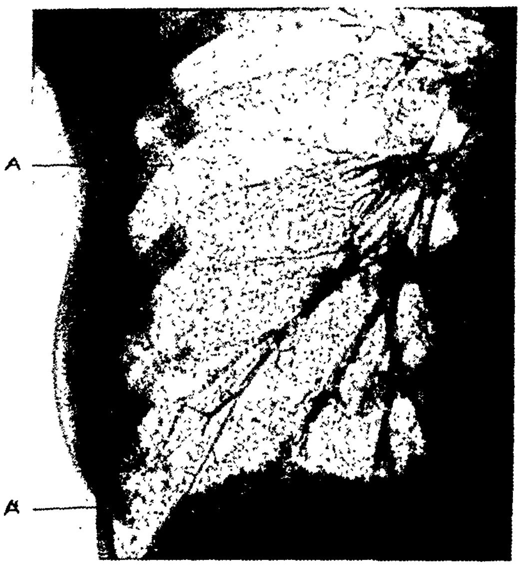

Fig. 16.

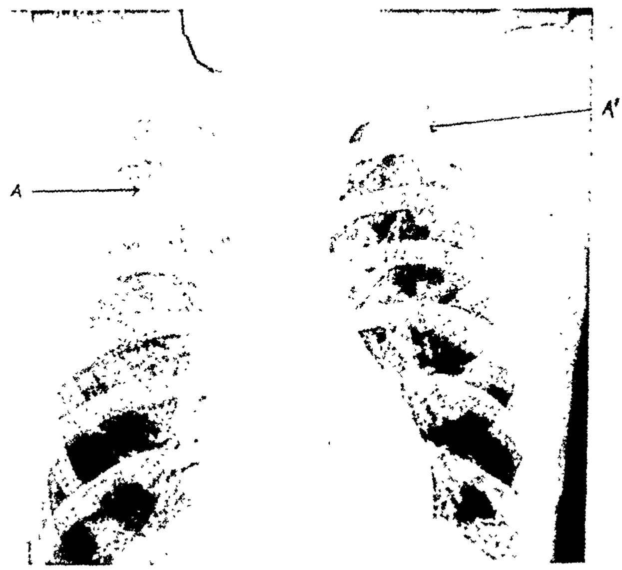

Fig. 17.

Fig. 16. Roentgenogram made after the injection of iodized oil, showing the bronchial pattern (A and A') on which part of the pockmarks develop.

Fig. 17. Roentgenogram showing a pleural cap at the apex of the lower lobe (A and A') beneath which there is massive collagenization. This finding reminds one of rudimentary angel wings folded up on the back of the patient. (*Lent by Dr. Pendergrass, Philadelphia, Pennsylvania.*)

The foregoing does not apply to cases of acute silicosis, in which the roentgenologic pattern is a general nondescript haze or cloudiness. Workers exposed to huge amounts of certain dusts containing silica, perhaps silica in combination with some alkaline chemical or gases, develop lesions with great rapidity, passing from an early stage to the terminal stage in a few months, or, at most, in two or three years. Such patients develop dyspnea, sometimes with a dry cough. They die of avascularization of the lung, and these avascular areas may possibly break down because of their poor blood supply. It is to be remembered that in cases of acute silicosis roentgenograms do not show nodules or pockmarks or even areas of massive collagenization.

The question of compensation is vital, and deserving of far greater consideration than it has received thus far. Industry should unquestionably compensate the relatively few workers incapacitated by lesions acquired and developed in the pursuit of their work. But other controversial questions arise. Some of those which have not been satisfactorily answered are:

1. Should the able-bodied laborer who has a job and wants to keep it be compelled to have an x-ray examination each year and be fired as soon as peribronchial markings or diffuse mottling are manifested on the roentgenogram?

2. Should an employer refuse to hire a man because he has such markings due to previous exposure lest the applicant develop more advanced stages of pneumoconiosis (silicosis)?

3. If a laborer is fired, with compensation which is small in comparison with his wages as a full-time laborer, shall he still receive compensation if he obtains labor in a non-dust-hazard industry?

4. When roentgenologic findings increase without the appearance of dyspnea, cough, or any other symptoms, should the laborer be allowed to work?

5. At what period in the development

of the disease should the laborer begin to receive compensation?

6. Should not those laborers who develop acute silicosis and are rendered totally incapacitated and die within two or three years, be compensated for silicosis even though they do not have the typical nodulation on which the definition is based?

7. Should a tuberculous patient who has worked in a dust-hazard industry but whose roentgenogram shows no evidence of silicosis be compensated for tuberculo-silicosis because of his previous exposure?

It is not our object in this article to answer these questions, but the fact that they are numerous, various, and controversial indicates the necessity of some comprehensive investigation based on factual evidence, both medical and social, so that the incapacitated silicotic victim may be adequately compensated, and unjustified claims may not be a direct burden on industry and thereby an indirect burden on society.

Our investigation reveals that most roentgenologists see occasional cases of pneumoconiosis (silicosis) and welcome the opinion of one making an intensive study of the disease. A few roentgenologists see a tremendous number of cases and are sufficient unto themselves for the diagnosis of cases in their communities. For the convenience of those who rarely see cases, and in the hope of obtaining a comprehensive view of the subject, we solicit the continued co-operation of both these groups. We have begun a registry of silicotic cases, photographing films sent to us, recording the findings, comparing them, and reporting our opinion when returning the films.

This article may tend to be verbose, for it has been most difficult to be convincing without a larger number of illustrations than we have been able to include. In the near future we will have available for distribution scrolls of films showing the four findings of pneumoconiosis (silicosis) and the varying degrees of involvement. Each roentgenogram will have the findings typed and photographed on it, morbid changes and roentgenologic patterns being correlated whenever possible. These films may be studied in conjunction with the article, and will present a far more comprehensive study than we have been able to give in words.

SUMMARY

We are indebted to 24 physicians throughout the country for roentgenograms and autopsy specimens which have made this investigation possible.

It is universally conceded that roentgenograms are important in the diagnosis of pneumoconiosis (silicosis). In our opinion, both worker and employer suffer unless trained roentgenologists are employed for the interpretation of such roentgenograms.

Roentgenograms of subjects who have inhaled certain dusts over a long period of time show findings which are shadows of deposits of morbid tissue composed mostly of collagen. The amount of morbid tissue may be slight or almost great enough to fill the thoracic cage. Since dust is inhaled in both lungs, the distribution is bilateral and relatively symmetrical. Morbid tissue occupies space that would otherwise be filled with air, and casts shadows on the roentgenogram which correspond to it in size, shape, and distribution.

PATTERN APPROACH

Roentgenologic findings will be considered under two main groups: (*A*) characteristic *patterns* on the roentgenogram; (*B*) *regional distribution of densities* on the roentgenogram. Roentgenograms of pneumoconiosis (silicosis) manifest four main patterns which have been discussed in the following order:

1. Accentuated hilar and linear markings.
2. Small white spots on a dark background—nodules.
3. Small black spots surrounded by white rings—pockmarks.
4. A general haze or cloudiness.

1. *Accentuated Hilar and Linear Markings.*—These were said by Pancoast to

Fig. 18. Fig. 19.

Fig. 18. Classified by Dr. Smith, of South Africa, as "ante-primary." This roentgenogram shows a relatively early stage of fine bilateral mottling, more marked in both mid-lung fields. The roentgenologic shadows are cast by foreign-body flecks, opaque to both light and x-rays, which have been phagocyted out of the alveoli and deposited in the stroma of the lung, and by small strands of collagen laid down along the branches of the blood vessels and bronchi or laid down as rudimentary whorls. *(Lent by Dr. McArthur, Noranda, Quebec.)*

Fig. 19. Roentgenogram showing a diffuse mottling in both lower lung-fields with large dense shadows in both upper mid-lung fields. The fine mottling of the lower mid-lung field is caused by the same finding described under Figure 18, but the dense shadows above are caused by massive collagenization in these regions. *(Lent by Dr. Pound, New York City.)*

constitute a "perivascular–peribronchial–lymph-node" manifestation of pneumoconiosis. The shadows are due to a deposit of morbid tissue composed of dust-laden phagocytes and collagen laid down like an envelope around blood vessels and bronchi. The phagocytes may be loaded with silica (non-opaque, refracting crystals) or other foreign body flecks (opaque, non-refracting crystals), but in either event are a contributing cause to the accentuated hilar and linear markings.

2. *Nodules—Small White Spots on a Dark Background.*—South African observers gave the name of "nodules" to the small, clear-cut white discs on the roentgenograms of pneumoconiotic (silicotic) patients. These nodules are shadows of whorls of collagen distributed in the parenchyma of the lung, most marked in the mid-lung fields. They may be so small as to be scarcely discernible to the naked eye, or two, three, four, or five nodules may be connected by collagen strands to form a conglomerate nodule.

Nodules have been considered pathognomonic of silicosis, and are the basis of the definition and diagnosis, but nodules may contain a preponderance of opaque, non-refracting flecks (not silica), and we, therefore, use the term "pneumoconiosis" with "silicosis" in parentheses when referring to this lesion.

3. *Pockmarks—Small Dark Spots Surrounded by White Rings.*—This is a roentgenologic finding of importance which we believe has not been recognized before, and it is, therefore, dealt with at length in the article. Pockmarks are shadows of collagen laid down around the terminal blood vessels and bronchi, or collagen around bronchi when viewed on end.

4. *General Haze and Cloudiness.*—A general haze and diffuse cloudiness, bilateral, symmetrical, and not sufficiently dense to obscure the ribs, is the chief roentgenologic finding in acute silicosis. It is caused by the following morbid changes: (1) thickening of the walls of the alveoli; (2) deposits of various types of

Fig. 20.

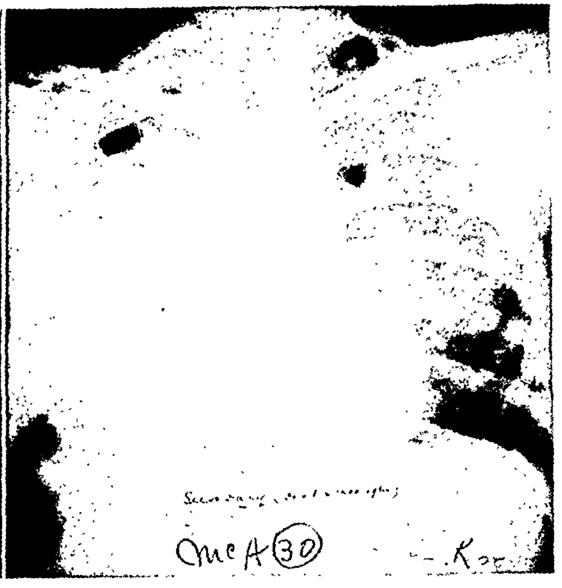

Fig. 21.

Fig. 20. Shows diffuse mottling in both lung-fields, plus a smooth shadow of collagenization in the upper right mid-lung field. In the left lung one observes diffuse mottling in the lower lung-field, and in the mid-lung field massive collagenization on which infection has been ingrafted. (*Lent by Dr. Corcoran, Scranton, Pennsylvania.*)

Fig. 21. Classified by Dr. Smith, of South Africa, as "secondary with a positive tuberculous sputum." Diffuse mottling of the left lower lung-field. There is a dense, homogeneous shadow in the right mid-lung field due to massive collagenization, probably with some infection. Cavitation of the left upper lung, and a large cavity or localized pneumothorax in the right lung. The patient died six months later. (*Lent by Dr. McArthur, Noranda, Quebec.*)

material within the alveoli; (3) envelopes of collagen surrounding the smaller blood vessels and bronchi.

Massive Collagenization—We have discussed the four patterns in cases of pneumoconiosis (silicosis) in which the disease has progressed sufficiently for the pattern to be well marked but not developed to such a degree that the pattern is obscured on the roentgenogram. Often two or more of the roentgenologic manifestations described may be observed on the same roentgenogram, but one pattern usually predominates.

As the disease progresses, collagen may develop in great quantities, and appear in the following three regions: (1) as a "pawnbroker's sign" in the mid-lung field, seen more frequently on the right; (2) in the pleura at the apex of the lower lobe; (3) in the upper lung-fields.

Ingrafting of Infection—Pyogenic or Tuberculous.—As collagenization increases, the blood supply is impaired and gross infection—pyogenic, tuberculous, or both—may be ingrafted, or, in the case of acute silicosis, develop in the avascular areas. Inflammatory and tuberculous processes do not develop until massive collagenization has occurred. Before infection is ingrafted the markings of pneumoconiotic (silicotic) lungs are not displaced or altered in position, because pneumoconiotic collagen, unlike collagen of tuberculous or inflammatory lesions, does not contract. After infection occurs the trachea may be deviated, the pleura "tented," and the costophrenic angle obliterated.

Cavities and Pneumothoraces.—Cavities may be formed by a breaking down of the tuberculous or pyogenic infection, or a combination of the two. They occur in the upper third of the lung and are of three types: (1) a cavity caused by a tuberculous or non-tuberculous area of collagenization; (2) a spontaneous, localized pneumothorax, usually near the apex; (3) a split pleura, high up on the lateral wall about two or three inches from the apex.

the pattern of accentuated markings and also acute silicosis.

Our examination of about two hundred roentgenograms from various industries and sections of the country led to one outstanding revelation—that subjects do not complain of dyspnea, cough, or expectoration in pneumoconiosis (silicosis) until the development of massive areas of collagenization or areas of collagenization on which infection, either tuberculous or pyogenic, has developed. They may work 15, 20, or 30 years without symptoms, though their roentgenograms show shadows of extensive morbid tissues.

In the case of acute silicosis, which develops and terminates within two or three years, the subject does have symptoms, and dies of avascularization of the lung. We believe that such cases should be compensated, though they do not now come within the definition of silicosis.

The question of compensation is vital and is deserving of far more consideration than it has received thus far. It is not our object to discuss the questions which were brought up in the article in regard to it, but to emphasize the necessity for a comprehensive investigation based on factual evidence both medical and social, so that the incapacitated silicotic victim may be adequately compensated, and unjustified claims may not be a direct burden on industry.

APPENDIX

Fundamental Principles Underlying X-ray Diagnosis in General.—It is well known that x-ray has ability to penetrate objects opaque to light. The ray is obstructed by objects in proportion to their radiological density, or inversely in proportion to the penetration of the x-ray. For example, in the human body rays are obstructed by bullets, bones, and kidney stones in proportion to their density, the bullet obstructing the rays to a greater degree than the bones. Bones, on the other hand, are more opaque than muscles and soft tissues and, therefore, obstruct a larger proportion of the x-rays.

Roentgenograms were formerly referred to as "shadow graphs" or "skiagraphs," and are sometimes likened to silhouettes, but the roentgenogram is more than a silhouette for it records the opaqueness of objects.

In a well-exposed roentgenogram with a properly selected penetration of the ray, bones, muscles, blood, and fat will cast shadows of varying intensity, the bones obstructing the rays to the greatest extent and, therefore, appearing as the lightest area on the roentgenogram. Other less solid objects appear light in proportion to their solidity in the body. More opaque substances such as bismuth, the iodide oils, and dyes are often injected or ingested into the hollow cavities to aid in x-ray diagnosis. Areas of increased solidification in the body always appear as areas of lightness on the roentgenogram, whereas regions of the body containing air (accessory sinuses, mastoids, lungs, etc.) do not obstruct the rays as much as the soft tissue which surrounds them, and appear as blacker areas. While these areas of increased density in the body appear as varying degrees of light areas on the roentgenogram, we will translate these shadows into areas of anatomic and pathologic density.

There is about equal division of opinion as to whether roentgenograms should be reproduced as negatives or positives. When describing the roentgenographic print, or positive slide, the term "density" applied to the roentgenogram corresponds with pathologic density in the lung. For those who prefer to observe the negative findings, or black on white, the terms will be reversed. In this article, illustrations are given in both the negative and positive.

Special Principles Applicable to the Diagnosis of Chest Lesions.—The lung contains a far greater amount of air than any other organ of the body, so even the soft tissues of the lung, being in contrast to air, are shown on the roentgenogram as areas of diminished density, which, translated into anatomic structures, means areas of increased density, the degree of increase

being in direct proportion to the degree to which they obstruct the x-rays. Therefore, these soft tissues of the lung appear as definite shadows on the roentgenogram, causing a characteristic pattern in the normal lung. Soft tissues of the same density occurring in airless regions of the body would not be observed on a roentgenogram.

Almost all morbid tissues in the lung increase its solidity, and are manifested on the roentgenogram as areas of diminished density, which, after translation, we refer to as areas of increased density, whereas morbid accumulations of air in the lung reduce its solidity and are manifested as areas of diminished anatomic density, as in the case of emphysema and over-distention of the lung as seen in cases of non-opaque foreign bodies. Thus different morbid processes as they occur in different portions of the lung obstruct or increase the transmission of x-rays, causing peculiar patterns that are more or less characteristic of the morbid lesions. The more air there is in the lung the more clearly are the disease areas shown, and as the lung collapses the tubercles or nodules become obscure.

We remember well a controversy which took place in the early days of pulmonary roentgenology, concerning whether or not a miliary tubercle would cause an x-ray shadow. Cohn made an x-ray examination of a small section of a tuberculous lung which he knew to contain miliary tubercles, and this section which was, of course, collapsed, failed to show the miliary tubercles on the roentgenogram. He, therefore, maintained that it would be much more difficult to show these through the muscles of the thoracic cage; but he overlooked the fact that the tubercle in the collapsed lung was surrounded by tissue of relatively the same density, whereas in the inflated lung during inspiration it was shown in contrast to air. Roentgenograms of autopsy specimens soon showed that tubercles were not visible in collapsed lungs, but that when the same lung was inflated they could be identified and readily counted. In life, the same thing is true. Miliary tubercles and the normal markings are evident during inspiration, but they are obscured when the lung is even partly collapsed by pneumothorax. Thus degrees of inflation, or the depth of inhalation, are important factors in x-ray technic. Ernst (7), of St. Louis, in discussing densities in silicotic lungs, illustrated clearly the difference between roentgenograms made during inspiration and those made during expiration.

When a lung is prepared in the conventional way for a microscopic examination, it contracts and is further diminished in size by fixation, so that a section of the lung that extends all the way from the hilus to the pleura can be mounted on a single microscopic slide. The contraction of the microscopic section is due largely to the elimination of air, which causes the alveoli and bronchi to contract and appear much smaller than in the living subject. Thus the microscopic findings, particularly the size and shape of the alveoli and bronchi, cannot be compared with those same structures in the living, functioning lung.

In the normal lung, where the walls of the bronchi are thin, the air in them cannot be readily differentiated from the air in the adjacent alveoli, but in the typical pneumoconiotic (silicotic) lung there is a thick envelope of collagen surrounding the bronchi, and the air within the two may be differentiated on the roentgenogram. The larger and medium-sized bronchi radiate from the root of the lung and one is able to trace the course of the air they contain. As viewed longitudinally, such a bronchus appears to be like a hollow tube, while a bronchus that projects directly anteriorly or directly posteriorly looks like the end of a pipe, or a circle surrounded by increased density. These bronchi, seen on end, are occasionally observed in the normal lung, but they become much more evident in the pneumoconiotic lung and account in part for the "pockmarks" on the roentgenogram.

TECHNIC OF CHEST X-RAYS

While each roentgenologist has his own personal technic there are certain funda-

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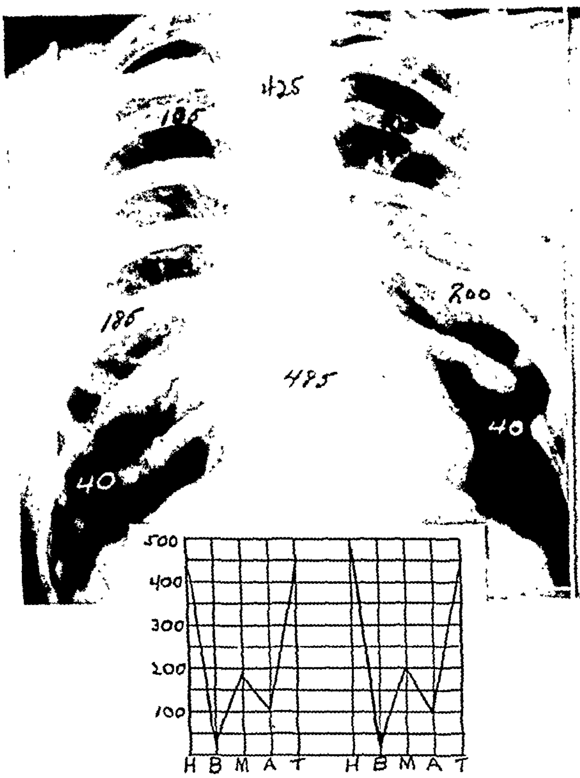

Fig. 25.

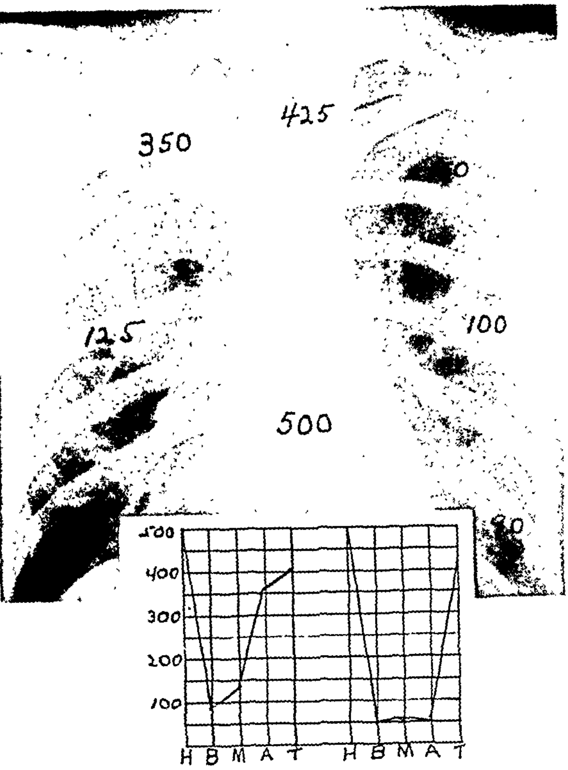

Fig. 26.

Fig. 25. Photometric readings recorded on a roentgenogram showing the peribronchial-perivascular type of pneumoconiosis, with increased ventilation at the bases and diminished ventilation in the mid-lung fields. When readings are recorded on a chart, the chart gives a typical capital *W* for each lung, or a double *W* for both lungs.

Fig. 26. Photometric readings recorded on a roentgenogram showing pulmonary tuberculosis of the right upper lobe. When the readings are charted, the chart shows a square root sign on the affected side, and a capital *U* on the normal side.

such an exposure or less the left border of the heart is clear-cut on the roentgenogram. When an exposure of one-tenth of a second is used the left border of the heart is blurred if the heart is caught in the stage of contracting or relaxing, but if the exposure happens to catch the heart in complete diastole or systole, the motion is *nil*. Actually the heart is observed to be at rest in about one-half of the films made with one-tenth of a second exposure. If it is necessary to make an exposure of one-fourth of a second, there is so much motion to the heart and the adjacent lung that it is just as well to increase the time to one-half of a second or more, and in order to obtain a film of proper density increase the contrast by using less penetration.

As stated before, the ideal time is one-twentieth of a second or less. Shorter exposures or less penetration may be used for special regions in the chest which are over-ventilated, or in special cases involving the bases of the lungs—as in emphysema. On the other hand, when the ventilation of the lung is displaced by a large mass of morbid tissue, the detail in these dense portions of the advanced lesions may be shown, as Pancoast and Pendergrass (2) pointed out, by the use of the Potter-Bucky diaphragm. This technic will bring out pneumoconiotic (silicotic) nodules which would otherwise be obscured by consolidation or interstitial deposits of collagen, but we wish to emphasize the fact that the Bucky technic must be used only as a supplementary procedure for the examination of advanced lesions.

Study of the Roentgenogram.—Roentgenograms should be studied by properly

transmitted illumination and care should be taken to eliminate all extraneous light, particularly the reflected light from behind the observer. A rheostat, or some device for increasing or diminishing the intensity of the light in the illuminating box, is essential. The use of the fluoroscope for the study of pneumoconiosis (silicosis) is relatively limited because it affords no permanent record with which to compare subsequent examinations. It is of value in studying the excursion of the diaphragm as this can be recorded on a translucent paper behind the screen, but in all controversial cases it is better to make two roentgenograms with the patient in the same position, one during inspiration and the other during expiration.

Diagnostic Value of Paper Roentgenograms Compared with Films.—Some thirty odd years ago, we suggested the use of paper instead of plates which presented storage and breakage problems, but it soon became apparent to us that paper roentgenograms were less satisfactory, and when the film came into vogue and the problems of breakage and storage were solved, the advantages of paper were eliminated. Recently the use of photographic paper in place of films has been advertised and widely advocated by a firm of commercial radiographers who seek the business of making surveys of employees in dust-hazard industries. They offer to make paper roentgenograms at a contract price lower than is possible for the roentgenologist using individual films or even rolls of films. This company submitted to the New York Society of X-ray Economics samples of paper and film roentgenograms, both made on the same group of tuberculous and pneumoconiotic (silicotic) patients.

On the paper roentgenograms the ribs, the outline of the heart, calcified glands, and grosser lesions were visible, but the smaller lesions, particularly the smaller tubercles, nodules, and linear markings could not be seen. This would have led the roentgenologists into serious errors of omission in their interpretations. The diagnostic value of films made of the same patient was so much greater that there was literally no comparison. The use of paper roentgenograms for silicosis surveys was particularly unfortunate, and an expensive economy for the industrialists. It is well known that in the early stages of the disease clinical symptoms are absent, and that one must depend upon satisfactory roentgenograms for diagnosis. The paper roentgenogram fails to show the early findings clearly, and hence an industry using them would undoubtedly accept as free from pneumoconiosis (silicosis) employees who would later develop symptoms, become claimants, and represent a compensation burden. The compensation of one individual so accepted would be far in excess of the price difference between paper and film roentgenograms.

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A VISUALIZATION STUDY OF FIBROTHORAX: IDENTIFICATION OF THE CARDIOVASCULAR STRUCTURES[1,2]

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IN patients having massive pulmonary fibrosis, or "fibrothorax," the conventional roentgenogram fails to reveal the essential features of the thoracic cardiovascular system. However, visualization of these structures is now possible, for, recently, we have developed a method for the visualization of the chambers of the heart, the pulmonary circulation, and the great vessels (1, 2), and have reported examples of its value in the normal individual (3) and in patients having heart (4) and lung (5) disease. It has been possible to see the cavity and wall of each chamber, the interventricular septum, the pulmonic and aortic valves, the pulmonary artery and wall, the entire pulmonary circulation, and the thoracic aorta with its wall and the branches from the arch.

In this paper we wish to illustrate the value of this method in a patient in whom there was displacement and obscuring of the heart by pulmonary and pleural fibrosis and to show that it is now possible to visualize the cardiovascular structures as well as the esophagus and the tracheobronchial system.

Method and Roentgenographic Technic.—Visualization studies were made in the lateral, the left anterior oblique, and the frontal positions. By using a rapid stereoscopic cassette shifter, we were able to make two exposures per injection and, thus, to visualize both sides of the heart and the large vessels. The right cephalic vein, which measured 8 mm. in diameter when distended, was used for each injection since it was the only large vein available; the injections were made through a special 12-gauge needle-stopcock unit. Before injection of the contrast substance, the arm-to-pulmonary and the arm-to-carotid sinus circulation times were determined and found to be three and eight seconds, respectively. Thus it was possible to learn the time of the arrival of the contrast substance in both the right side of the heart and the pulmonary arterial tree, and the left chambers and the aorta. The patient was then seated before the cassette and 35 c.c. of a 70 per cent solution of diodrast injected in two seconds. In addition to the usual wave of heat felt immediately after injection, the patient developed a small area of edema of the lower lip which was promptly relieved by 0.2 c.c. of epinephrine, and subsequently was prevented by premedication with this drug. Immediately after injection, the patient was allowed to go home. The absence of detectable injury to the vein was proven by careful examination and by its repeated use (1, 2).

For the frontal views, the following exposure factors were used for this patient in whom the postero-anterior diameter of the chest was 7.5 inches; milliamperage, 300; distance, 72 inches; exposure, one-twentieth second; 66.2 kv. (peak) for the control film (Fig. 1) and 80.5 for the contrast films (Figs. 4, 5, and 6). In order to secure good contrast and detail, it was found necessary to overpenetrate the films showing the contrast substance as in bronchography (Figs. 4, 5, 6, 8, 9, 11, and 12). For the left anterior oblique projection, the same factors were used except that the voltage was increased to 97 kv. (peak) (Figs. 7, 8, and 9). The lateral films (Figs. 10, 11, and 12) were taken at 100 ma., distance 72 inches, exposure one-fifth second, and 90 kv. (peak).

[1] This is one of a series of papers contributed by friends and former pupils of I. Seth Hirsch, M.D.

[2] This investigation was aided by a grant from the Department of Medical Research of the Winthrop Chemical Company, Incorporated.

Case Report.—M. R., a 36-year-old Italian housewife, was first seen in January, 1938, because of cough and hemoptysis. Ever since the occurrence of whooping cough at the age of four years, she had had episodes of coughing, termed "bronchitis," which were never incapacitating. After the birth of her second child, in 1925, she was examined and found to have a "lung condition," but no roentgenogram was made. Except for an occasional "chest cold" she considered herself well until a month prior to her first visit, when she had "pleurisy" in the right lower axillary region, and, in addition, cough, scanty mucoid expectoration, blood streaking on two occasions, and an hemoptysis of 30 c.c. once. There was considerable lassitude and a loss in weight of ten pounds. She never complained of dyspnea although she occasionally reported wheezing.

Fig. 1. Fig. 2.

Fig. 1. Conventional roentgenogram. Bilateral apical fibrosis with multiple small excavations in right upper lung-field. Fibrosis of the entire right lung, particularly apex and base, causing displacement of trachea, mediastinum, and heart. The cardiac outline cannot be seen. Minute opacities in right upper lung-field due to retained lipiodol.

Fig. 2. Frontal bronchogram. Note curvature and widening of trachea with its bifurcation in the right side of the chest. Sacculated bronchiectasis throughout the right lung.

Physical examination at that time showed the patient to be well developed and nourished and in no discomfort. She was afebrile. Her weight was 83 pounds and her height 4 feet 9 inches. Examination of the chest revealed deviation of the trachea to the right and dullness over the upper two-thirds of the right side of the chest, front and back. The breath sounds were bronchovesicular in character and were accompanied by numerous moist râles, many of which were consonating. Occasionally, wheezing was heard over the right anterior side of the chest. The heart was displaced into the right side of the thorax; the sounds were of good quality and no murmurs were present. The blood pressure was systolic 120, diastolic 85. There was no clubbing of the fingers or toes.

These signs and symptoms, in addition to the presence of multiple excavations in the right upper third of the lung-field (Fig. 1) and the apical fibrosis on the left side, suggested active pulmonary tuberculosis. The chronic nature of the process was indicated by the displacement of the trachea and the heart to the right and by the pleural thickening at the base and apex.

However, after six concentrated specimens of sputum proved negative for tubercle bacillus, active tuberculosis seemed unlikely, and it was decided to investigate further by bronchoscopic examination and, later, bronchography. Bronchoscopy revealed narrowing of the right main bronchus and the presence of a moderate amount of mucoid secretion. The bronchogram (Fig. 2) showed marked deviation of the trachea to the right with displacement of the bronchi, and also sacculated bronchiectasis involving the right upper, middle, and lower lobes; a lateral film showed the sacculations in the upper lobe more distinctly. The esophagus lay to the right of the thoracic spine which it crossed at the level of the eleventh vertebra to enter the stomach. In the roentgen kymograph (Fig. 3),[3] the ventricular and pulmonary arterial waves to the left of the spine could be seen clearly, whereas the aortic waves to the right of the spine were barely detectable and other waves were absent. The electrocardiogram was normal except for high voltage; the Wassermann test was negative.

During the past year of observation the patient has been fairly well. Her weight has increased to 96 pounds and she has had only one recurrence of cough and expectoration of blood-streaked sputum. Serial roentgenograms have remained unchanged and the sputum has been negative for tubercle bacillus on two more examinations.

CONTRAST ROENTGENOGRAPHIC STUDIES

Postero-anterior Position.—Figure 4 was made one second after the beginning of injection. The right cephalic, axillary, and subclavian veins are filled with the contrast substance and there is reflux into the basilic vein. The right subclavian vein is kinked and foreshortened as a result of the shift of the mediastinum and its contents to the right. The innominate vein lies to the right of the trachea and follows its contour. The upper left arrow indicates the junction of the right and left innominate veins forming the superior vena cava, which courses downward to the right

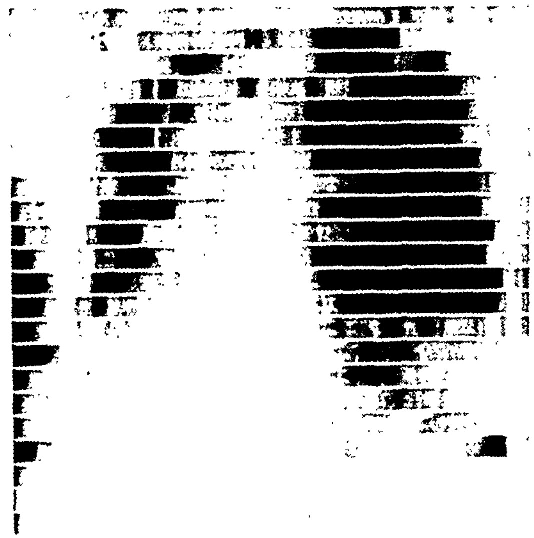


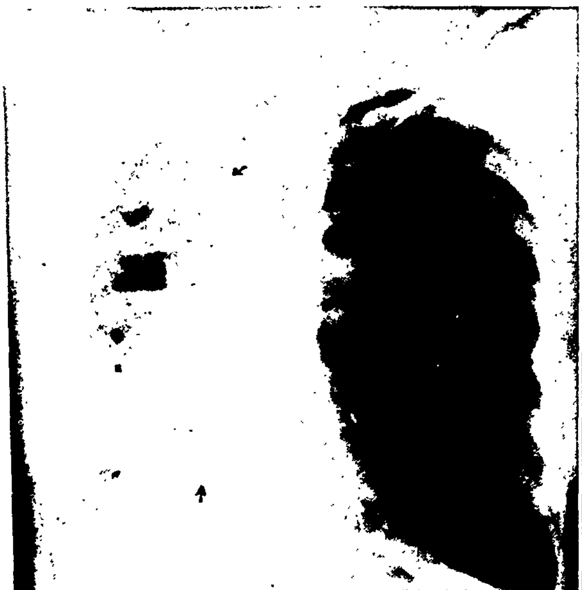
Fig. 3. Roentgen kymograph. Pulsation of the left ventricle, the left pulmonary arterial tree, and the aorta only are discernible. Note absence of waves in the lower right lung-field.

of the trachea and the right main bronchus; it appears irregular on its medial side. The right auricle is indicated by two small arrows and the auriculo-ventricular groove by a large arrow.

In Figure 5, made at three seconds after the start of injection, the right innominate vein and superior vena cava still show faint filling, while the right auricle, the right ventricle, and the pulmonary arterial tree are opaque. The lower arrow points to the diaphragmatic border of the right ventricle. The auricle and the ventricle appear to be rotated slightly toward the left. The pulmonary conus is not well outlined but lies immediately below the left pulmonic sinus which is denoted by the arrow over the spine. The pulmonary artery courses backward and divides into right and left branches. The dwarfed right trunk which terminates in a few small branches is indicated by the upper right arrow. The left trunk and its major divisions appear more prominent and larger than the normal.

[3] Obtained through the courtesy of I. Seth Hirsch, M.D.

At eight seconds (Fig. 6), the left ventricle and the thoracic aorta are well outlined and are found to be displaced far to the right. The interventricular septum is indicated by the lower left arrow and the aortic sinus and ascending aorta by the upper right arrow. The pulmonary veins can be seen entering the left hilum, whereas



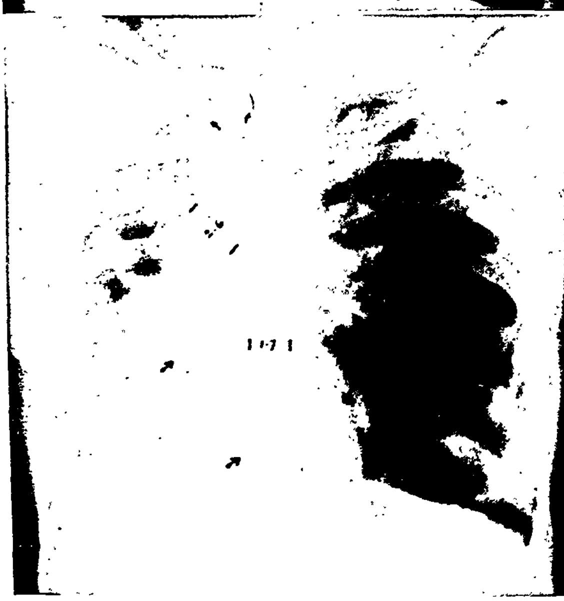


Fig. 4 (*upper left*). Contrast roentgenogram, frontal view. Note kinking of the right subclavian vein and displacement of innominate vein and superior vena cava. The right auricle (denoted by darts) is beginning to fill. The upper left arrow indicates junction of innominate veins; lower left arrow, auriculo-ventricular groove.

Fig. 5 (*upper right*). Contrast roentgenogram. The lower right arrow points to diaphragmatic contour of right ventricle, and the arrow over the spine indicates the left pulmonic sinus. The upper right arrow denotes dwarfed right branch of the pulmonary artery. Note paucity of blood vessels to right lung and rich vascularity of left lung.

Fig. 6 (*lower left*). Contrast roentgenogram. The left ventricle and aortic arch are displaced into right side of chest. Lower right arrow points to interventricular septum; the arrow above it to right aortic sinus. The right subclavian, the right common carotid, and the left axillary arteries are indicated by darts. Note pulmonary veins at left hilum.

Fig. 7 (*lower right*). Conventional roentgenogram in the left anterior oblique position (35 degrees). Note obscuring of right cardiac border.

these vessels cannot be identified on the right side. The innominate artery which arises at the aortic arch may be seen dividing into the right subclavian and the right

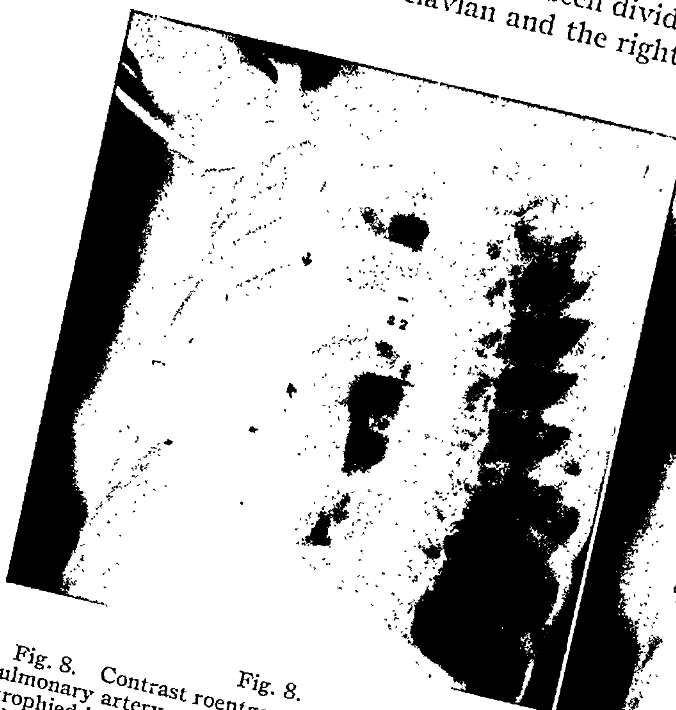


Fig. 8.

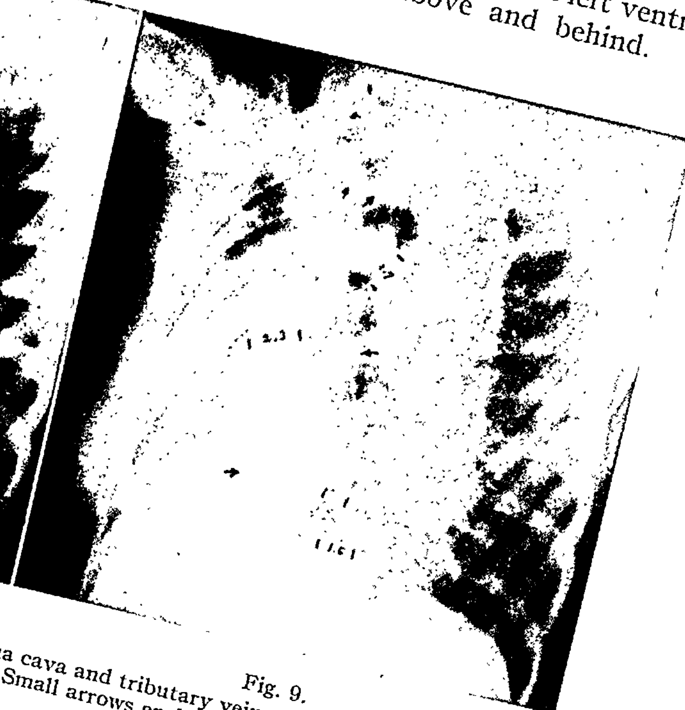


Fig. 9.

Fig. 8. Contrast roentgenogram. The superior vena cava and tributary veins, the right auricle, and the pulmonary artery and its main branches are opaque. Small arrows enclose auricle; larger arrows indicate atrophied branches of right main artery.

Fig. 9. Contrast roentgenogram. The left arrow lies on a left pulmonary vein; the right arrow indicates the left ventricle and interventricular septum; the ventricular wall is enclosed by parallel lines. The entire thoracic aorta is opaque. Darts indicate three main branches from the aortic arch and the major subdivisions of the innominate artery.

common carotid arteries which are indicated by small arrows. High in the left axilla is the axillary artery marked by an arrow.

Left Anterior Oblique Position.—Roentgenoscopy showed that the best view was obtained with a rotation of 35 degrees. In Figure 8, made at two and one-half seconds, the superior vena cava and its tributaries can be seen emptying into the right auricle, which is bracketed by small arrows. The right ventricle which apparently is in contraction is not opaque whereas the pulmonary artery and its left branch are well outlined. The shrunken upper and lower branches from the right main trunk, which are poorly defined, are denoted by arrows.

Figure 9 was made at eight seconds. The left pulmonary veins, the left auricle and ventricle, and the thoracic aorta with the branches from the arch are opaque. The lower right arrow rests on the interventricular septum and points to the left ventricle; the auricle lies above and behind. The aorta, which can be followed from its origin to the diaphragm, is normal in size, but the aortic arch is displaced to the right and is more rounded than usual. The three vertical arrows indicate the innominate, the left common carotid, and the left subclavian arteries. The innominate artery divides into the right common carotid artery which can be followed to the neck and the right subclavian artery and its continuations which are visible as far as the arm. The corresponding arteries on the left side also can be seen.

Lateral Position.—In Figure 11, made at two and one-half seconds, the right auricle, the right ventricle including the pulmonary conus, the pulmonary artery, and the left main branch with its subdivisions are opaque. The rounded density above the lowest arrow is the right auricle; behind

and above it lies the left auricle (posterior arrow), and in front of it the right ventricle, which is indicated by the arrow next to

Fig. 10. Conventional lateral roentgenogram.

the sternum. The pulmonary conus is embraced by parallel lines as is the larger pulmonary artery above it. The left branch of the pulmonary artery breaks up into superior and inferior divisions whereas the right branches are ill-defined.

The left auricle, the left ventricle, and the thoracic aorta are opaque in the roentgenogram made at eight seconds (Fig. 12). The vertical arrow indicates the left ventricle which is not clearly outlined. The ascending aorta, including one of the aortic sinuses, and the descending aorta are filled with opaque medium and are normal in size and contour. The transverse aorta is obscured by the pulmonary disease.

DISCUSSION

The conventional methods of investigation of the chest in fibrothorax, consisting of ordinary roentgenography assisted by contrast visualization of the bronchi, the esophagus, and the pleura, roentgen kymography, planigraphy, bronchoscopy, and sputum examination, permit the diagnosis of fibrothorax and recognition of the etiology and gross anatomical changes. But they fail to disclose the location and the structural and functional state of the heart, the great vessels, and the pulmonary circulation because of the obscuring pulmonary disease. Consequently, it is impossible to recognize pathologic conditions in the cardiovascular structures in the thorax by ordinary technic.

In the present case, conventional methods have established the diagnosis of fibrothorax and bronchiectasis and have indicated the probable rôle of tuberculosis in the etiology because of the bilateral apical involvement. The extensive pulmonary fibrosis and the displacement of the heart and the other mediastinal structures into the right side of the thorax are shown clearly in the usual roentgenogram (Fig. 1). Bronchoscopic examination revealed stenosis of the right main bronchus, and excluded foreign body and neoplasm as etiologic factors. The presence of extensive sacculated bronchiectasis involving the entire right side is shown in the bronchogram (Fig. 2). The cardiac silhouette, however, is completely obscured in the ordinary roentgenogram. Roentgen kymography (Fig. 3) permitted recognition of segments of the left ventricular border, the aorta, and the left pulmonary vessels but failed to reveal the right border of the heart and the right pulmonary blood vessels.

By means of contrast roentgenography of the cardiovascular system, it has been possible to resolve the unintelligible densities in the customary roentgenogram into their component parts. The four chambers of the heart, the great vessels, and the pulmonary circulation become visible, and changes in the size, shape, and position can be detected. The degree of displacement of the mediastinum is indicated by the kinking of the right subclavian vein and by the location of the superior vena cava (Fig. 4) which can be followed from its origin in the junction of the innominate veins to the heart. The right auricle is normal in size but unusually conspicuous in the frontal position (Figs. 4 and 5), suggesting that the heart has been rotated toward the

left as well as displaced; this interpretation was proven incorrect, however, by subsequent study in the left oblique and lateral positions in which the main axis of the heart was found to be rotated to the right. The right ventricle is not well visualized but appears to be normal; the pulmonic conus definitely is not enlarged, as shown in Figure 11. The pulmonary artery (Figs. 5 and 11), however, seems to be slightly enlarged and rotated toward the right side; the left main branch (Figs. 5 and 11) likewise is larger and lies more transversely in the chest, probably as the result of the rotation of the heart and pulmonary artery. The abundant vascularity of the left lung is strikingly contrasted with the few stunted vessels on the right side. The finding of decreased vascularity in the diseased lung is in harmony with the anatomical investigation of Wright (6), the combined anatomical and roentgenographic studies of Birkelo and Brosius (7), and the angiopneumographic studies of Lopo de Carvalho (8, 9).

Fig. 11.

Fig. 12.

Fig. 11. Contrast roentgenogram, lateral position. The inferior arrow indicates the right auricle, the posterior arrow the unfilled left auricle, and the anterior arrow the right ventricle. The pulmonic conus, the pulmonary artery and the left branch with its subdivisions are opaque. Note absence of visualization of right branches.

Fig. 12. Contrast roentgenogram, lateral position. The posterior arrow points to the left auricle now filled with opaque medium. The vertical arrow denotes the left ventricle. The ascending and descending positions of the aorta are well visualized. The transverse aorta is poorly defined.

The left auricle and ventricle are well visualized in Figure 9 and are normal in size and shape. The location of the left auricle directly behind the left ventricle in this position of the chest (left anterior oblique, 35 degrees) confirms the impression that the heart is rotated to the right, for normally this exposure is obtained only with a rotation of from 45 to 60 degrees. The widening of the aortic arch in the frontal position (Fig. 6) and its unusually transverse position in Figure 9 with a rotation of the thorax of 35 degrees show that the aorta, too, is rotated as well as displaced to the right. Except for displacement the branches from the aortic arch appear to be normal.

For the sake of completeness we shall review briefly a case of left-sided fibrothorax and bronchiectasis described recently (5) and which presents almost a mirror image of the changes exhibited by the present case. The heart and mediastinal structures were displaced toward the left instead of the right side and as a result

the left subclavian and innominate veins were kinked and foreshortened. Of greater interest, the heart, the pulmonary artery, and the aortic arch were rotated toward the involved left side so that these structures in the frontal view appeared as though in the right anterior oblique projection. No circulation to the involved lung could be detected, whereas the blood vessels to the uninvolved side appeared to be increased in size and number.

Our limited experience in fibrothorax consisting of these two cases does not warrant final conclusions regarding the cardiovascular changes in this condition. In both right- and left-sided involvement, the heart and mediastinum are shifted toward the involved side and in each case the rotation of the heart and great vessels was toward the diseased lung. Further study is necessary to determine the mechanism of this rotation and to find whether or not it is a constant occurrence. In both cases, there was striking diminution or absence of pulmonary blood vessels to the involved side.

SUMMARY AND CONCLUSIONS

In this report we have described a case of right-sided fibrothorax due to bronchiectasis. Attention was called to the inadequacy of the usual methods of study and to the value of contrast roentgenography of the heart and thoracic blood vessels in this condition. It was possible to identify the size, the shape, and the location of the superior vena cava, the cavities of the heart, the pulmonary circulation, and the thoracic aorta. The heart and the great blood vessels were displaced into the right side of the chest and also rotated in the same direction. There was no detectable enlargement or other abnormality of the heart. The left branch of the pulmonary artery was slightly enlarged and the pulmonary circulation to the left side increased, in striking contrast to the dwarfed right branch and the almost complete avascularity on the involved side. This report demonstrates the value of contrast roentgenography of the cardiovascular system in a patient having fibrothorax.

We wish to thank the Department of Roentgenology of Bellevue Hospital for co-operation in this study.

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PRIMARY ULCER OF THE JEJUNUM[1]

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WHILE ulcer of the jejunum secondary to a gastrojejunal anastomosis is not uncommon, primary ulcer of the jejunum in the absence of such operative interference is very rare.

Sestier (1), in 1829, described a case of acute peritonitis following spontaneous perforation of ulcer of the jejunum.

Wagner (2) described the case of a young man, 18 years of age, who died as a result of a wall collapsing on him. At autopsy, at a point six inches distal to the duodenojejunal junction and opposite the mesentery, there was a sharply delimited oval perforation; the margin was partly undermined. The lesion had the appearance of a chronic ulcer of the jejunum which had temporarily been prevented from perforation by adhesions to the great omentum. As a result of the accident, the adhesions were broken loose with ensuing perforation and peritonitis. Wagner believed that the ulcer was the result of the corrosive action of gastric juice although in an attenuated degree.

Taylor (3), in 1865, described the case of a man, aged 45 years, who after violent physical exertion complained of intense abdominal pain and died. At autopsy a severe peritonitis was found, and a perforation of the jejunum the size of the head of a pin. The opening appeared to have been the result of an ulcer which gave way as the result of abdominal strain.

Reverdin's (4) patient was a male, 55 years of age, with a vague history of abdominal trauma. Autopsy revealed a punched-out ulcer situated on the free border of the intestine in the mid-portion of the jejunum.

In Brigidi's (5) case of ulcer of the small intestine, the condition was found in a male, aged 40 years, who died of pulmonary disease. Autopsy revealed ulcers in the jejunum and ileum, the specimen being preserved at the Pathological Institute, at the University of Genoa. Pathological examination revealed no evidence of caseation or gummas. There was no evidence of nephritis. It was his opinion that the ulcers arose on the basis of catarrhal inflammation.

Simpson (6) described the case of a man, 56 years old, who at the onset of his illness complained of slight pain in the region of the stomach and vomiting. By the following morning he was found in a state of collapse and died shortly thereafter. Autopsy revealed a single ulcer of the jejunum, about six inches distal to the duodenojejunal junction. The ulcer was six millimeters in diameter, irregularly circular in outline, with clean-cut edges, and had perforated through all the coats. There was no evidence of chronicity. The ulcer had an appearance similar to that of a perforating gastric or duodenal ulcer. Simpson considered the possibility that the jejunal ulcer might have originated as the result of trauma from a foreign body, although no such substance was found in the alimentary canal, except a few shreds of partially masticated wood fiber in the colon.

In the case described by Dodson (7), perforation of a small chronic ulcer of the small intestine about eight feet from the stomach occurred in a 57-year-old male. The perforation followed abdominal trauma.

Jankowski (8) described a case of perforation of a jejunal ulcer in a male, aged 48 years. Autopsy revealed a funnel-shaped perforated ulcer the size of a pea, which he considered to be a simple ulcer. Near the perforated lesion was a second jejunal ulcer which had not perforated.

Schmilinsky (9), in 1910, reported the case of a woman, 63 years of age, who had complained of abdominal pain for years and who had suffered a hemorrhage from the

[1] This is one of a series of papers contributed by friends and former pupils of I. Seth Hirsch, M.D.

alimentary tract on two occasions. Operation showed a stenosing ulcer of the jejunum four centimeters distal to the duodenojejunal junction. Pathologically the ulcer resembled a gastric or duodenal ulcer.

Arkin (10) described the pathologic findings in a male, 65 years old. A history could not be obtained as the patient was in a coma when admitted. Autopsy revealed, in addition to a gummatous meningitis, gummas of the liver, spleen, and kidney, a syphilitic osteitis, and the presence of several ulcers of the jejunum. One ulcer was also found at the splenic flexure and another of a similar nature in the rectum. A detailed study of one of the jejunal ulcers was made. Arkin believed them to be of syphilitic origin and described the presence of the spirochaeta pallida in the lesion.

In the report by Cade, Roubier, and Martin (11), a perforation of a jejunal ulcer occurred 60 centimeters from the duodenum in a male, aged 25 years. Microscopic study of the margin of the perforated ulcer showed an intense inflammatory infiltration. There was no evidence of any specific infection. Pathologically it had the appearance of a simplex ulcer.

In Richardson's (12) case, the patient, 47 years old, gave a history of recurring attacks of severe general abdominal pain. Following one attack he noticed black stools. Roentgen examination was negative for renal calculi; no gastro-intestinal roentgen examination was made. At operation an indurated area was felt in the small intestine, due to a stricture, on the anterior surface of which was a perforation one-eighth inch in diameter. The intestine was opened, and an annular ulcer was found encircling the bowel at the point of the stricture. This appeared to be about two feet distal to the duodenum. The ulcer was resected. Microscopic examination showed evidence of a chronic ulcer.

The records of the Massachusetts General Hospital showed only one similar case; this was in a 48-year-old female. Operation revealed a perforation of an ulcer, apparently in the jejunum. Microscopic examination showed it to be a simple ulcer. There was no evidence of either syphilis or tuberculosis in either of the two ulcers reported.

Barber (13), in reporting his case of primary ulcer of the jejunum, stated that in a personal communication Dr. Symmers, Director of the Pathological Laboratory at Bellevue Hospital, had stated that he had no record of any preceding case. Barber's patient had been operated on twice for a perforated gastric ulcer. Finally, after being symptom-free for some time, he had a sudden attack of severe pain in the region of the umbilicus which necessitated a third operation. This time, in addition to a generalized peritonitis and a healed ulcer of the pylorus, there was a perforated and moderately indurated ulcer of the jejunum one centimeter in diameter, and about two centimeters distal to the duodenojejunal junction. The patient made an excellent post-operative recovery.

Ebeling (14) found two cases of primary ulcer of the jejunum at the University of Pennsylvania Hospital between the years 1921 and 1932. Including his own personal case, he found a total of 47 cases described in the literature from 1927 to 1932. A radiographic study made in his case showed stasis in the duodenum and jejunum with obstruction in the proximal jejunum. The roentgen diagnosis was ulcer or adhesions. The clinical preoperative diagnosis considering the clinical history was jejunal ulcer. Operation revealed a stenosing lesion of the jejunum, six inches from the ligament of Treitz. Approximately four inches of jejunum were resected. Pathologic examination disclosed a shallow ulcer.

According to Ebeling, the majority of the ulcers were located in the upper jejunum. Of those that had not perforated, four were in the first loops of jejunum, two were in the upper jejunum, and one in the midjejunum. Of those that had perforated, nine were in the upper loop, ten in the upper jejunum, four were in the midjejunum, and four in the lower jejunum. The majority of these ulcers were localized opposite the attachment of the mesentery.

Stricture of the bowel at the site of ulceration was commonly present. In Ebeling's case, the stenosis was due mainly to a constricting spasm of the ulcer-bearing area. The ulcers were described as being punched-out, predominantly circular, and similar in appearance to chronic ulcers of the stomach and duodenum. In size, they varied from about four millimeters to two centimeters. In those ulcers that had perforated, the site of perforation was often minute. Microscopic examination showed round-cell infiltration and fibrosis. In the few cases in which enlarged mesenteric lymph glands had been reported, examination showed changes due to chronic inflammation. In nine of the cases, additional ulcers were found.

There is no record of any case of primary jejunal ulcer showing the presence on histological examination of any aberrant tissue either gastric or pancreatic.

In addition to the case of primary jejunal ulcer which was radiographed by Ebeling, further reports of radiographic examinations in such cases are those of Murphy, Walton, Ravdin, and Harris.

In the case reported by Murphy (15), radiographic examination revealed obstruction to the outlet of the stomach and involvement of the gall bladder. The preceding history had been that of gastric disturbance for 15 years. The attacks consisted of epigastric pain occurring from one to three hours after meals. The pain was relieved by vomiting but not by food. There were tarry stools on one occasion. The pre-operative diagnosis was duodenal ulcer. At operation, an ulcer of the duodenum was found. In addition, another ulcer was found in the first portion of the jejunum associated with slight stenosis. Murphy stated that this was the second time he had seen a primary ulcer of the jejunum. A posterior gastro-enterostomy was done. The ulcer remained *in situ*, so that no histologic study was possible.

Walton (16) reported the case of a woman,

Fig. 1.

Fig. 2.

Fig. 1. Appearance of narrowed jejunum 45 minutes after the ingestion of barium.
Fig. 2. Appearance of narrowed jejunum one hour after the ingestion of barium.

45 years old, with a history of recurring attacks of "stomach trouble" for 19 years. The pain, located in the epigastrium, occurred several hours after eating and was often relieved by food. Occasionally the pain woke her from sleep about 2 A.M. The symptoms gradually became worse. Roentgen examination failed to disclose any organic lesion, and operation revealed the stomach, duodenum, gall bladder, and appendix to be normal. However, in the jejunum, three feet from the duodenojejunal flexure, there was an area of induration, two inches long, to which the omentum was adherent. The area of involvement was resected. On opening the intestine, a round ulcer similar in appearance to that of a gastric ulcer was seen. Histologic examination disclosed only evidence of chronic inflammatory changes.

In Ravdin's (17) case, the patient complained of pain in the epigastrium and right upper quadrant, which radiated across the upper abdomen to the left and occasionally to the back. The pain occurred about two hours after meals, and was not relieved by food. Radiography showed obstruction high up in the jejunum. At operation, there was an annular sclerosing mass encircling the jejunum about twelve inches from the duodenaljejunal junction. The mass was resected, the diagnosis being sarcoma or carcinoma. Pathological examination of the margins showed chronic inflammatory tissue. The final diagnosis was chronic lymphadenitis and chronic jejunal ulcer.

Owing to the neutralization of any excess gastric acid, Ravdin believed it highly improbable that peptic digestion plays any etiologic rôle.

In the case reported by Harris (18), the patient, a male aged 48 years, had complained of upper abdominal pain and vomiting of bile-stained material. After subsidence of the attack, symptoms recurred suggestive of a gastric ulcer. Radiographic examination showed a niche in the left upper quadrant which was interpreted as being due to an ulcer on the posterior wall of the stomach. Autopsy revealed two perforated jejunal ulcers opposite each other—one on the anterior and one on the posterior wall. The location of the ulcers was four inches beyond the duodenojejunal junction. The benign nature of the lesions was corroborated by microscopic study. Nothing is stated in the report regarding the presence of aberrant gastric or pancreatic tissue. The niche originally noted in the radiographic examination and which had been interpreted as being due to a gastric ulcer had evidently resulted from barium retention in a jejunal ulcer.

Recently we have had a personal experience with a case of primary jejunal ulcer which was carefully examined radiographically, and the diagnosis of jejunal ulcer established at operation.

This patient, V. C., aged 52, was accustomed to going on drinking bouts during which he took hard liquor steadily for from eight to twelve hours, and this he repeated every few weeks. Three weeks before admission he went on an alcoholic spree. Shortly thereafter he had griping upper mid-abdominal pain and vomiting. He felt better after the vomiting, but continued to have sharp, agonizing pain localized mid-way between the xyphoid process and the umbilicus. These pains were severe enough to cause him to double up at times. The pain kept him awake at night.

A radiographic study of the stomach and duodenum, as well as of the small intestine was made. This special study of the small intestine consists of the following procedure: After the ingestion of the barium, several films are taken of the stomach and duodenum; a 14 × 17 film is then taken every 15 minutes during the period of one hour. This is followed by a similar examination at two, three, five, six, and nine hours.

Radiographic examination of the proximal jejunum revealed an area of about one and one-half inches in length that was markedly narrowed. The contour was fairly smooth in outline. Along the lateral border of the narrowed area, at its proximal

region was a persistent small niche-like projection (Figs. 1, 2, and 3).

Diagnosis.—The roentgen diagnosis was inflammatory jejunitis. A newgrowth could not be entirely ruled out. The sig-

Fig. 3. Appearance of narrowed jejunum two hours after the ingestion of barium.

nificance of the niche-like area in the involved jejunum, persistent in all the films, was not recognized. About four days after the completion of the radiographic study, the patient developed the clinical evidence of an acute abdomen which necessitated immediate surgical intervention. As determined at operation (performed by Dr. Berry) and as noted in the resected specimen, this niche-like area presumably represented the region through which perforation occurred.

Operation revealed the following: In the mid-portion of the jejunum was a small perforation on its mesenteric border. Proximal to this, the intestine was considerably dilated; distal to the perforation it was contracted. The peritoneal cavity beneath the gastric omentum was filled with turbid fluid and with occasional flecks of fibrin. The diseased area of jejunum was resected.

Macroscopic Examination.—The specimen consisted of a piece of the jejunum 20 cm. in length. The proximal 12 cm. was dilated. The intestinal wall here was thicker than normal. The folds of the

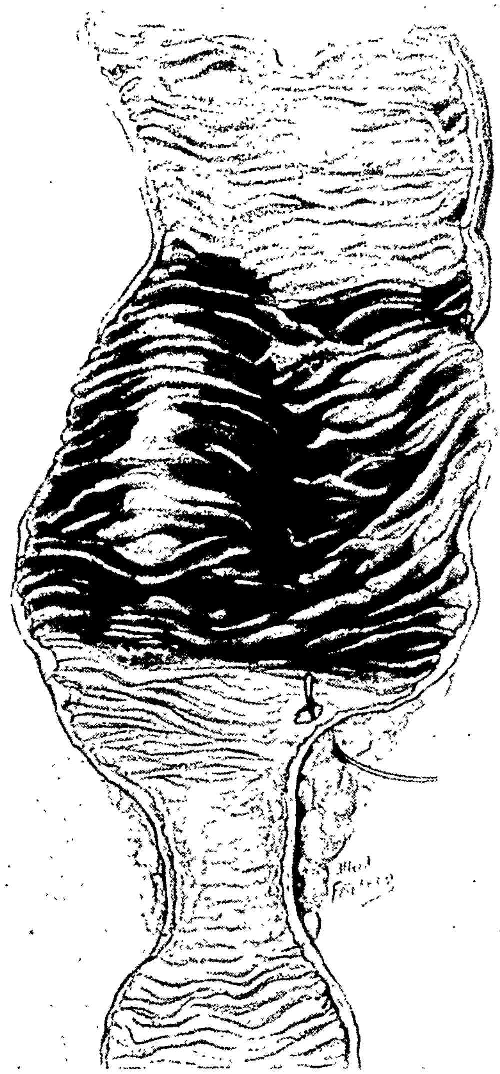

Fig. 4. Reproduction of resected specimen of jejunum showing perforated ulcer with a probe through it.

mucosa were flattened and the subserosal blood vessels somewhat dilated. There was a constriction of the intestinal wall 12.5 cm. from the proximal end. Here the wall was slightly thickened for 2 cm. and the mucosa flattened. There was an opening in the mucosa on the mesenteric border 5 mm. in diameter about which the mucosa

was thickened and harder than normal. The distal 7.5 cm. of the jejunum was normal in diameter, the serosal and mucosal surfaces appearing natural. The probe passed through the opening for 8 mm. toward the mesentery proximally and perforated the serosa. On section, the tract was brown, the wall of the intestine thickened and grayish white in color.

Microscopic Examination.—The mucosa showed edema, increased vascularity and congestion of the blood vessels, and infiltration with plasma cells, lymphocytes, and numerous eosinophiles. The muscularis was slightly thickened and a few chronic inflammatory cells were present. The serosa was thickened; congested blood vessels were present; inflammatory cells and an occasional giant cell were seen. Large giant cells were seen among the fat cells of the mesentery. Sections through the tract show that the latter was lined by chronic inflammatory tissue. The tract penetrated through the entire intestinal wall into the mesentery where the acute inflammatory reaction was intense. Numerous blood vessels in the mesentery showed thickening of the media (Fig. 4).

Comment.—This case is of interest for the following reasons:

1. The extreme rarity of primary jejunal ulcer.
2. The value of the fractional method of studying the small intestine as outlined above in the roentgen demonstration of organic lesions of the small bowel.
3. It is worthy of note that pathological examination revealed no evidence of any aberrant tissue, either gastric or pancreatic. In none of the cases previously reported of primary jejunal ulcer, has there ever been any evidence of aberrant gastric or pancreatic tissue.
4. The rôle of gastric acidity in the genesis of primary jejunal ulcer cannot be considered as having any significance because of the absence of aberrant gastric tissue, and because it is difficult to assume that gastric secretion leaving the stomach and duodenum unaffected would retain sufficient power to continue as a factor in the development of an ulcer in the jejunum well beyond the ligament of Treitz.

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BONE RAREFACTION AFTER TRAUMA TO LARGE JOINT REGIONS WITHOUT FRACTURE[1]

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LOCAL regressive soft-tissue changes after an acute trauma without fracture to a large joint region are fairly common and familiar. For instance, it is recognized that a violent wrench, blow, or bump to the knee can lead to severe and disabling local muscle atrophy. Occasionally, the latter is even associated with the presence of one or more small areas of rarefaction in the spongiosa near the joint. Very rarely, without having induced a fracture, an acute trauma to a large joint region instigates, in addition to soft-tissue changes, an impressive degree of bone rarefaction. In these cases, the rarefaction extends far along one or all of the bones entering into the formation of the joint, and involves both the spongiosa and the cortex. That this sequence of events can occur at all does not seem to be well known.

Fig. 1. Fig. 2.

Fig. 1. Roentgenograph showing extensive rarefaction of femur; note severity of changes in condylar region.

Fig. 2. Roentgenograph showing the rarefied femur of Figure 1 in the antero-posterior projection.

Cases presenting rarefaction of long bones after trauma (without fracture) to large joint regions are analogous in many respects to cases showing rarefactions of hand or foot bones after trauma (not infrequently without fracture) to the wrist or ankle region. Though fairly familiar clinically and roentgenographically, the latter such cases, often discussed under the head of "Sudeck's atrophy" or "Leriche's dis-

[1] This is one of a series of papers contributed by friends and former pupils of I. Seth Hirsch, M.D.

ease" of the hand or foot, are but poorly understood anatomically.[2] Indeed, there has been practically no opportunity for anatomic examination of adequate material from cases of post-traumatic rarefaction of the hand or foot bones. As a matter of fact, there seems to be no satisfactory discussion of the pathology of post-traumatic (but not post-fractural) rarefaction of bones in any location. In the present paper, an attempt is made to supply this deficiency, at least in part, and to correlate the pathologic with the roentgenographic findings in such cases. A discussion of the pathology of post-traumatic rarefaction of long bones ought to shed some light upon post-traumatic rarefaction of the hand or foot bones as well. It should likewise be of help in understanding the changes which take place during the pre-collapse stage in post-traumatic rarefaction of vertebral bodies (Kümmell's disease).

Clinical and Roentgenographic Aspects.—As has already been pointed out, cases of pronounced bone rarefaction following upon trauma (without fracture) to the region of a large joint are extremely rare. In these cases, the overlying soft parts also become modified in various ways. In particular, there is usually some muscle atrophy, and the skin may present changes attributable to local vasomotor and trophic disturbances. The region may be slightly swollen or perhaps only appear so on account of thinning of the limb above and below it in consequence of muscle atrophy.

Sinding-Larsen (4) has described an instance of pronounced post-traumatic rarefaction in which it was the knee joint region that was affected. The case was that of a man, 40 years of age, who was struck on the inside of the right knee by a falling herring barrel. This knee swelled immediately and gradually became stiff. For 11 months subsequently, the patient was treated on the assumption that the condition was a low-grade osteo-articular tuberculosis. Then, still suffering from pain, swelling, and limitation of motion in the knee, he came under the care of Sinding-Larsen, who also thought at this time that the condition was a tuberculous gonitis. However, the latter disease was excluded by a negative tuberculin reaction and by the peculiar "spotty" rarefaction detectable roentgenographically in the femur, patella, and tibia. Diathermy and cautious exercise of the part brought about prompt clinical recovery and incidentally showed that the condition was not tuberculosis. However, it is significant that even 27 months after the injury, rarefied spots were still discernible roentgenographically, though with difficulty, in the affected knee-joint bones. Since there was no operative intervention, no opportunity was afforded for anatomic study of this case.

Roentgenographs from another case of post-traumatic rarefaction of the knee are pictured in Haglund's text on orthopedics (5). No specific anatomic data are given on this case. Recently, Sudeck (6) too has discussed an instance of post-traumatic rarefaction of the knee region. His subject, a man 52 years of age, had received a relatively slight injury to the knee, which was painful for only a day or so at first. After ten days he again began to suffer from pain, and motion became limited in

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[2] In this connection, it seems appropriate to consider briefly the question of so-called "acute bone atrophy." Indeed, from the roentgenographic point of view, post-traumatic rarefaction of hand or foot bones belongs in the category of "acute bone atrophy." The initial modification is represented by an unclear, hazy appearance, especially of the cancellous ends of the metacarpal or metatarsal bones and of the carpal or tarsal bones. From about two to three months after the trauma, these regions, and also the spongy ends of other affected bones, often show small, roundish, closely set rarefactions. The affected bones now present a distinctly "mottled" or "spotted" appearance which is characteristic of the early stage of "acute bone atrophy." It should be pointed out, however, that a "mottled" or "spotted" appearance is observed roentgenographically in the hand and foot bones in a variety of other conditions also. In fact, such pictures were first described by Sudeck himself (1) in connection with inflammations of interphalangeal joints and soft tissues of the hand or foot. Dubs (2) observed spotty bone atrophy as a sequel of severe burns of the hand or foot; it also appears after freezing of these parts. The present writer has seen it in the hand of a patient suffering from neuritis and herpes zoster. Jaffe and Pomeranz (3) described it as occurring in the foot bones in connection with vascular disease of the lower limbs.

the affected region. Three months after the injury, the bone rarefaction was already clearly apparent roentgenographically. The case was also interesting in that it was a source of medico-legal controversy. That it became such is not surprising in view of the slightness of the original injury. No pathologic material became available for study in this case either.

The present writer has had the opportunity of studying material from a case showing a particularly severe post-traumatic rarefaction of a knee region.[3] In this case, the rarefaction was so conspicuous, especially in the femur, that a malignant tumor was thought to have developed in this bone and consequently the limb was amputated through the upper third of the thigh. This erroneous diagnosis, with its baleful consequences, is understandable in view of the deceptive roentgenographic appearances. The subject, a man 30 years of age, had jumped from a wagon and injured his right knee; he was unable to continue his work that day. Subsequently, he resumed his work, but accomplished it with some difficulty because of pain and limitation of motion of the knee. Nine weeks after the injury, there was some flexion deformity of the region and enough soft-tissue swelling to obliterate the bony points, and the knee region was tender to touch. Otherwise, the general health of the patient was good, and the body temperature was not increased. Clinical laboratory examinations showed nothing abnormal.

Roentgenograms, taken about ten weeks after the injury, show the knee in a position indicating flexion deformity. The lower half of the femur presents profound and extensive modification (Fig. 1). Specifically, the condylar regions reveal complete obliteration of their spongy architectural pattern. Instead of this, the lower end of the femur presents an obfuscated, cloudy, somewhat mottled ground-glass appearance. Furthermore, the condylar outlines show notches in some places and in others are so vague that they

Fig. 3. Roentgenograph showing post-traumatic rarefaction of the lower end of the humerus.

can hardly be traced. Proximally to the condyles, the rarefaction is still very pronounced. Viewed laterally, the shaft cortex shows longitudinal tracts of rarefaction, some of which are quite near its surface. In the anteroposterior projection, the extensiveness of these areas becomes apparent (Fig. 2). Nowhere along the femur is there any evidence of deposition of new bone by the periosteum. The patella, too, presents mottled rarefaction, and irregularity and obscuration of its outline. In general, the tibia and fibula for some distance below their upper ends are also so modified. In these bones, however, the alterations are by no means as pronounced as in the femur. The interpretation of these roentgenographic changes on the basis of the pathologic findings will be given presently.

The writer has, in addition, studied a case of post-traumatic rarefaction of the elbow region (Fig. 3). In this case, the changes were by no means so pronounced

[3] I am greatly indebted to William Boyd, M.D., now Professor of Pathology at the University of Toronto, for tissue and copies of roentgenographs, sent me some years ago, from this very unusual case, and for his kind permission to use this material.

as in the one just described. The subject was a young adult who had received a relatively mild injury to the outer side of the elbow which was followed by pain and considerable disability. A roentgenograph taken some time later disclosed the presence of rarefaction, involving the lateral epicondyle and the adjacent portion of the humeral shaft. The outline of the affected part of the humerus was irregular, and, in the anteroposterior projection, large roundish areas of rarefaction were also visible. In this case, too, material became available for anatomic study. A biopsy was performed, and the diagnosis of post-traumatic rarefaction was established.

Fig. 4. Roentgenograph of transverse slice from femur shown in Figure 1; the slice was taken about three inches above the knee.

Pathology.—Professor Boyd's note, accompanying the material from his case, gives some information on the gross changes in the femur. It appears that the outer surface of the lower end of this bone was found superficially undermined in some places while in others it had actually been eroded. In the interior of this part of the femur there was extensive resorption of the spongy osseous tissue, the latter being represented only by scattered gritty fragments embedded in fluid fatty marrow. The articular cartilage of the femoral condyles was not found altered.

The writer received for study a block of shaft and some modified spongiosa. A roentgenogram of a transverse slice of this block shows quite well the superficial undermining of the outer cortical surface and the complete erosion of this surface in some places (Fig. 4). It also shows a very uneven mottled rarefaction within the cortex. In certain of the more conspicuous rarefied areas, numerous thin-walled blood vessels embedded in a loose, fatty connective tissue were detectable, even grossly.

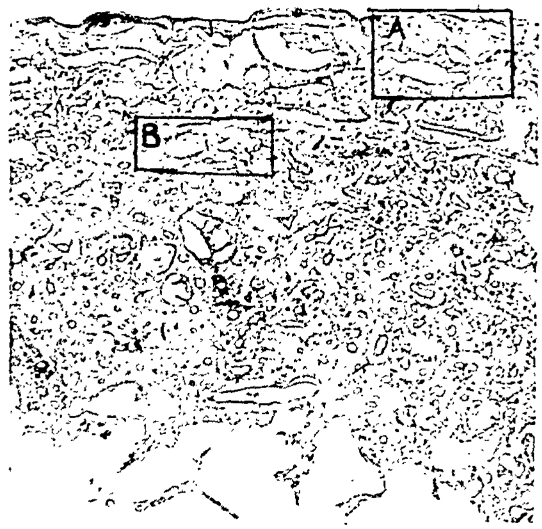

Fig. 5. Photomicrograph (low-power survey) showing the distribution of the rarefaction throughout the thickness of the cortex.

Sections made from transverse cortical slivers embedded in celloidin were examined microscopically. In these it can be seen that the diameters of a large proportion of the haversian canals are increased. Furthermore, the outlines of many of these canals are distorted, and the blood vessels which they contain are dilated and often engorged. One can also see an abnormal number of perforating (Volkmann) canals radiating from the enlarged haversian canals. Here and there, but particularly near the cortical surface, groups of enlarging canals have coalesced through resorption of the intervening osseous tissue, to form the large spaces visible grossly and appearing roentgenographically as rarefactions (Fig. 5). These spaces contain a loose and edematous

fibro-fatty marrow carrying numerous large, and, in life apparently engorged, thin-walled blood channels. Some of these channels abut directly upon the osseous borders of the spaces. The outlines of the spaces are irregular, and, even in connection with any one space, part of the wall may show osteoclasts in Howship's lacunæ (evidence of resorption) while another part of the wall may be found already lined by osteoblasts and smoothed out by newly deposited bone (Figs. 6 and 7).

Fig. 6.

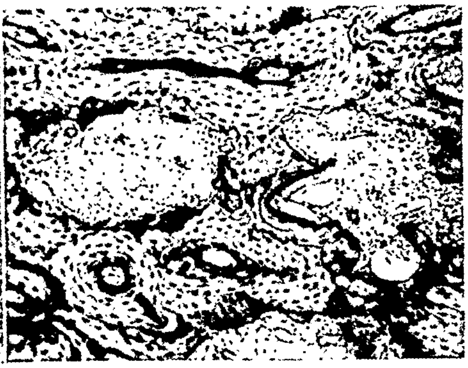

Fig. 7.

Fig. 6. Photomicrograph (moderate magnification) of area blocked out and marked *A* in Figure 5, showing the character of the enlarged and coalesced vessel spaces immediately under the cortical surface.

Fig. 7. Photomicrograph (moderate magnification) of area blocked out and marked *B* in Figure 5, showing the resorption and new bone deposition on the walls of the large cortical spaces.

In addition to enlargement of haversian canals and the formation of spaces representing their coalescence, there are also changes in the osseous tissue about and between the canals (Fig. 8). In the first place, the proportion of interstitially located bone has increased at the expense of the bone arranged around the canals to form haversian systems. Furthermore, the cement lines separating the haversian systems from the interstitial bone are more numerous, thicker, and much more irregular than they would normally be. These various changes are additional indications of the lively reconstruction which has been going on in the cortex of this femur. In regard to the interstitial osseous tissue, it is also to be noted that nuclei are largely absent from its bone-cell lacunæ. This suggests that this tissue is partially necrotic, although in interpreting this necrosis it should be remembered that nuclei also tend to be lacking in the interstitial osseous tissue of normal adult femoral cortex (3). However, the osseous tissue about the haversian canals (except in instances in which there is evidence that the haversian systems are undergoing reconstruction) does show bone cells in the bone-cell lacunæ almost throughout.

What is interesting when one examines the periosteal surface of the cortex is the absence of osteophyte-like new bone deposition by the periosteum. Not only has there been no re-enforcement of the cortex, but, instead, some of the large cortical spaces have extended until they are directly beneath the periosteum, producing defects in the cortical surface. On the medullary side of the cortex, abnormal spongification of the latter has occurred in some places. In the spongiosa proper, the intertrabecular marrow is fatty, somewhat abnormally fibrillar, and slightly edematous (Fig. 9). It contains, in general, a meager sprinkling of cells, mainly mononuclears, and here and there a small agglomeration of them. The original osseous trabeculæ have been largely resorbed, but such trabecular fragments as have persisted show evidence of reconstruction and regeneration.

Pathogenesis.—We do not know the instigating and mediating mechanisms responsible for the fact that trauma to a joint region is often followed by muscle atrophy and other local soft-tissue changes, and, sometimes, in addition, by pronounced bone rarefaction. It is probable that whatever these mechanisms may be, they are the same for the soft tissue as for the bone changes. The answer to this problem of pathogenesis seems to lie in the realm of neurophysiology, and more specifically in the field of neurovascular dynamics. However, mere disuse, even with the implication that it results in diminished nutrition, can hardly explain the whole complex of soft-tissue and bone changes in the affected part. On the contrary, the condition may develop despite continued use of the traumatized region, and furthermore, the anatomic changes in the femur described previously are not those characteristic of the simple smooth atrophy of inactivity. Notably, one does not see, in bones undergoing atrophy caused by inactivity, the numerous dilated and engorged blood vessels which are so prominent in the condition under consideration here. This condition of the vessels is certainly an important factor in the enlargement and erosion of the haversian canals and in the general rarefaction of the bone. It is possible that the state of dilatation of these vessels is due to a sort of reflex paralysis of their walls. This idea is suggested by the fact that in the cases of post-traumatic rarefaction of hand or foot bones the overlying soft parts are livid and cold.

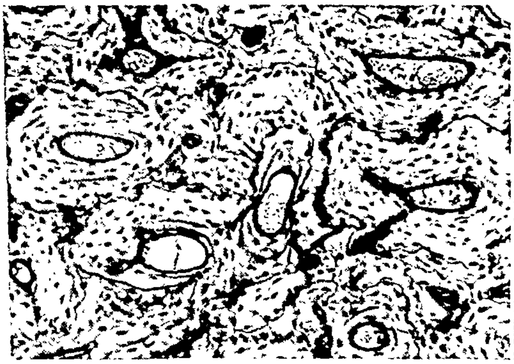

Fig. 8.

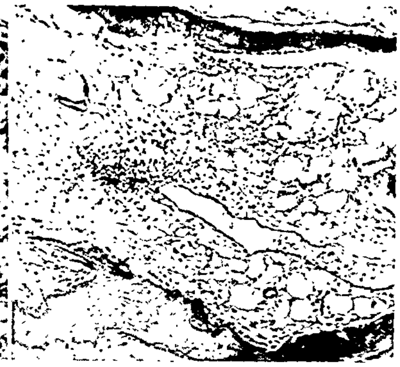

Fig. 9.

Fig. 8. Photomicrograph (moderate magnification) showing a more compact portion of the cortex; there is distortion of the outlines of the haversian systems and an excessive amount of interstitial bone as evidence of lively reconstruction.

Fig. 9. Photomicrograph (moderate magnification) showing spongy trabeculæ in the process of resorption and reconstruction; the edematous intertrabecular fatty marrow contains a collection of mononuclears.

DISCUSSION AND CONCLUSIONS

The preceding exposition has shown that an acute trauma (without fracture) to a large joint region may instigate severe rarefaction in the long bones of the vicinity. In association with this rarefaction, there are regressive changes in the overlying soft tissues. In particular, the muscles are likely to become very atrophic. The post-traumatic rarefaction in question is definitely uncommon. It has been noted more often in the knee region than elsewhere. Because it is rare and because the possibility of its occurrence is but little appreciated, the condition is usually misdiagnosed, at least when first encountered. Specifically, of the three instances cited in detail in which the knee region was involved, the first was held to represent a tuberculous arthritis, the second some other infectious arthritis, and the third a malignant bone tumor.

It is not surprising that such errors should occur. In fact, they are often made even in connection with post-traumatic

rarefaction of the hand or foot bones, which is much more common. Subjects affected with this condition are sometimes mistakenly held to be suffering from tuberculosis of the wrist or ankle bones. Or, instead, they are even labeled as neurotic because of the severity of the pain complained of in comparison with the objective changes. In cases in which this error is committed, the bone rarefaction is usually ascribed to mere inactivity. Again, the writer has seen an instance of traumatic rarefaction of the foot bones in which the subject was supposed to have a malignant tumor of the os calcis.

The instigating trauma in cases of post-traumatic rarefaction is sometimes a slight one, and may hardly be remembered by the patient. Already on this account, the condition may be incorrectly evaluated in some instances. That it can be misinterpreted even when it is recognized as being connected with a previous trauma has heretofore been indicated. It becomes apparent that in certain cases medico-legal injustices may result from such errors. On the other hand, a history of trauma is so common in skeletal disorders in general, that one should beware of concluding too readily in a given case that one is dealing with a post-traumatic rarefaction.

Anatomically, the bone rarefaction is manifested in porousness of the compacta and meagerness of the trabeculæ of the spongiosa. The rarefaction can be seen to be dependent upon hypervascularization, which is particularly prominent in the cortical bone. In the latter, the large resorption spaces are found filled with a loose, fibro-fatty connective tissue bearing numerous engorged blood vessels. If the bone regions rarefied are such as normally have thin cortices, these regions are likely to become so greatly weakened as to yield easily under functional strain. It may be on this account that persons with post-traumatic rarefaction of the hand or foot bones suffer so much pain when the affected parts are used. It may likewise be for this reason that vertebral bodies sometimes collapse after trauma, coming to manifest Kümmell's disease.

Post-traumatic rarefaction is a stubborn condition. Indeed, it is but slowly, if at all, that the affected bones re-acquire a completely normal roentgenographic appearance. However, even before there is substantial regression of the rarefaction, considerable articular function is usually already possible. Recovery is definitely favored by active use of the affected part, in association with physiotherapeutic measures such as diathermy and massage.

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THE TANGENTIAL IRRADIATION OF BREAST CARCINOMA[1]

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DURING a visit to the United States in 1937, I realized that the tangential method of treating malignant disease of the breast was by no means as widely used as it was in England. I feel, therefore, that Dr. Hirsch, though he knows the method well and employs it himself, will welcome a few words from me on this subject.

Until the latter part of 1921, I treated cases of breast carcinoma by three overlapping fields, at right-angles to the surface, giving the treatment at intervals of three weeks for about six months and often a second course of treatments for a period of three months. For years the voltage and filtration were gradually increased. Probably on account of this I began to realize, about the beginning of 1921, that some of the cases which we thought were recurrences in the lung, were, in fact, damage following x-ray treatment. These occurred only in some instances and were definitely more likely to occur when there had been old healed lung disease. As I had made x-ray examinations of the chest and mediastinum a routine in breast cases, this fact was soon established, and it seemed highly probable that the effect was due to a bacterial invasion of damaged tissues. It took some time to convince my radiological colleagues that this was true,

Fig. 1.

Fig. 2.

Fig. 1. Patient treated by three overlapping fields. Skiagram made one year after the commencement of treatment shows mottling in the lung, drawing across of the aorta, and drawing up of the left diaphragm. Before the treatment the chest was normal.

Fig. 2. Same patient ten years later. Note the more normal position of the diaphragm and the bronchiectatic cavities toward the apex.

[1] This is one of a series of papers contributed by friends and former pupils of I. Seth Hirsch, M.D.

but eventually the evidence became too strong to be controvertible.

Something had to be done, so, in the middle of 1921, I instituted the tangential or glancing method. Soon after this, I increased the filtration. A little later, I ordered the glancing method for a patient, but, owing to a misunderstanding, she was treated by the old method with the new filtration. The result was an acute burn of the lung, showing first about three weeks later. The case was followed through for years. The characteristics are, in the acute stage, a faint shadow like a pneumonia, but with less pain and no fever. This stage can only rarely be seen, but the later stages are the same in the acute and chronic cases. The most characteristic feature of the later stage is an extreme displacement of all the mediastinal contents toward the affected side (Figs. 1 and 2). Later they gradually return toward the normal position but never reach it: as they do this, a characteristic mottling is seen in the affected lung with clear spaces of an initiate bronchiectasis (Fig. 3). After several years, the appearance becomes that of typical bronchiectasis, though very often symptomless. In some cases the symptoms have been those of a chronic bronchiectasis: more often there is a tendency to bad bronchitis in the winter which eventually passes off. The mechanics of the condition are probably as follows: first, a sticky secretion in the smaller bronchi which blocks these bronchi, causing collapse of the lung; the mediastinal contents are, therefore, dragged across to the affected side as is usual with a blocked bronchus; bronchiectasis then supervenes and partially clears up later, if the blockage of some of the bronchi disappears.

The introduction of the tangential method of x-ray treatment has almost eliminated this trouble. Irradiation of the apex of the lung is inevitable in every case and one occasionally gets a mild degree of the trouble from this, when there has previously been disease at this point.

At first I used strips of lead and limited the beam from an open field by this means, but later I developed a special applicator.

Applicator.—This (Figs. 4, 5, and 6) in its final form has an opening 30 × 12 cm., but the beam is decentered so that the cen-

Fig. 3. Patient with mediastinal Hodgkin's disease who was treated by various fields directed on to the mediastinum and remained well until he got pneumonia in the right side about a year after the treatment. Skiagram taken four years after the beginning of treatment shows marked bronchiectasis, much displacement of the heart, aorta, trachea, and diaphragm. Since this skiagram there has been considerable improvement in symptoms, but only slight improvement in the radiographic appearance.

tral ray is 1 cm. from the straight side and 11 cm. from the oblique side. The central ray is not actually along the straight side, in order not to cut off rays from a broad focal spot in the tube. It will be realized that since the applicator is lined with lead or lead-rubber, the rays will not enter the body quite at the point where the edge of the straight side touches the skin, but about 1 or 1.5 cm. away. This can be avoided by shaping the applicators like those of Holfelder. Also, the greatest care must be taken to see that the rays go deeply enough into the superficial parts of the lung

to insure sufficient back-scatter to irradiate the deepest parts of the growth. The breast, axilla, and subclavicular regions are included in the fields.

Technic.—For the antero-internal field, the patient lies on the back with arms to the side, and a line is drawn to mark the incident line of the x-rays: the straight side of the applicator touches the skin 1.5 cm. from this. The space which lies between the upper part of the applicator and the tissues is built up with bags of powder of the same density as water: this usually consists of kaolin and sodium bicarbonate mixed in suitable proportions. The line of incidence is made semipermanent by my skin-ink ferric pyrogallate solution in alcohol and acetone, the formula for which is as follows:

Ac. Sulphuros, m. 5
Ac. Pyrogall, gram 1
Acetone, c.c.10
Liq. Ferri Chloridi U.S.P., c.c. 4
Sp. Meth. Industrialis ad., c.c. 20.

For the postero-external field, the patient lies on the side opposite to the lesion with both arms in the front. Sandbags are so arranged as to form a bridge over the lower arm and support the arm of the affected side in a horizontal position. The distance between the centers of the treatment edges will be about 20 to 25 cm. and a tilt of from 10 to 15 cm. in the fields toward the tangent is usually necessary.

The supraclavicular region must be treated in every case and it is not necessary to go through the steps in the evolution of the present method of doing this. What I do, is to give a field directed toward the mediastinum downward and inward to the neck, taking in a region well up the neck.

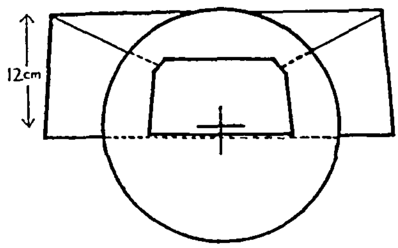

Fig. 4.

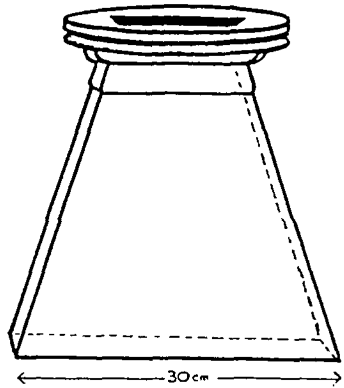

Fig. 5.

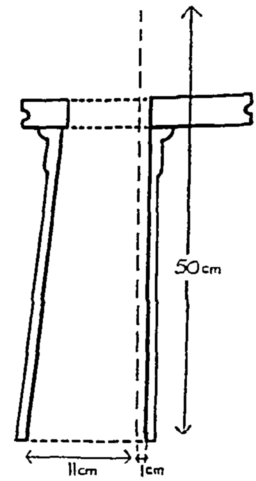

Fig. 6.

Figs. 4, 5, and 6. The writer's special applicator.

If palpable hard glands are present above the clavicle, quite a different method must be used. In such a case, the upper mediastinum is undoubtedly invaded by the disease, even if no enlarged glands are seen in the anterolateral skiagram: the outposts of the disease are always ahead of anything which is palpable. In these cases, the upper mediastinum must be treated by multiple ports of entry notwithstanding the possibility of lung changes afterward. The tangential treatment of the pectoral region would be wrong in such a case, as the pectoral skin will be required for the ports of entry into the mediastinum.

I had one case in which both supraclavicular regions contained hard metastatic glands and the mediastinum also showed enlarged glands in the skiagram. This case has remained well now for 14 years after the treatment without any lung changes and I have several other such cases

which have had prolonged periods, from five to ten years, of freedom from disease.

To return to the routine treatment, the incident dose D, at 350 kv. interrupted current and a Thoraeus filter is from 250 to 350 r per day for five days a week and extends from four to five and one-half weeks. The total incident dose, D, is from 2,100 to 3,000 r. The skin dose, D_o, is from 2,600 to 3,750 r. The tumor dose, D_x, is difficult to calculate but is approximately from 3,500 to 4,500 r, except in the subclavicular region and apex of the axilla, where a greater dose is needed and is, therefore, given. The dosage rate is from 18 to 20 r/min. Probably our meter reads low and rather more than this is given.

With 200 kv. continuous current and a Thoraeus filter, we reckon, at St. Bartholomew's Hospital, to give 2,250 r in 18 days, 3,200 r in 24 days, and about 3,800 r in four weeks at the point of lesion.

The inter-field distance varies from 16 to 26 cm. and the surface dose is calculated accordingly.

At the end of the treatment there is a sharp erythema just short of blistering, if the skin is kept dry. This increases for a few days and then subsides and only in rare instances causes subsequent trouble.

Differences from Holfelder's Method.—In this method the applicator is much wider and consequently the lungs tend to receive more radiation, as the rays from the patient's side of the applicator are much more oblique (Figs. 7 and 8).

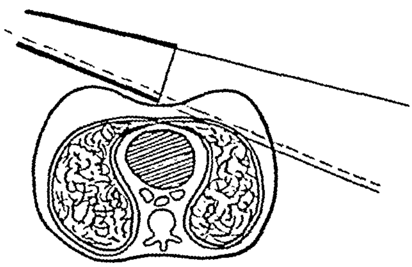

Fig. 7.

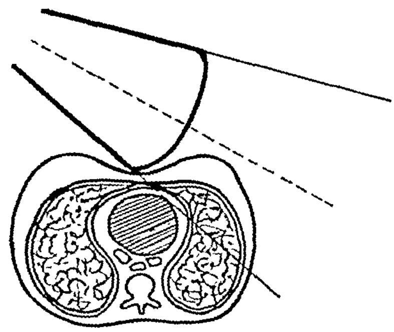

Fig. 8.

Figs. 7 and 8. Differences between the Finzi and the Holfelder applicators (slightly exaggerated).

I originally treated the external area with the arm drawn back but I now draw the arm forward and place the applicator behind it, as Holfelder does. With the much wider field (25 × 20 cm.) which he uses, Holfelder gets more back-scatter from his bolus, while I rely more on direct radiation. Apart from these differences, the methods have the same object and are essentially the same.

Other Applications.—For certain other regions, such as a one-sided skull-bone tumor, especially if the eye can be avoided by an oblique tangent, for a localized parotid tumor, for growths of the pinna, and so on, other applications have proved useful.

In conclusion, I may say that the tangential method is the one which we use as routine in suitable cases and it has given us complete satisfaction, the only disadvantage being that it requires anatomical knowledge and extreme care in application. The only contra-indications are involvement of the supraclavicular or mediastinal glands or the occurrence of distant metastases. Previous irradiation compels very serious consideration as to dosage and whether any further irradiation is justifiable.

CHRONIC RECURRENT INTESTINAL INTUSSUSCEPTION[1]

By MILTON G. WASCH, M.D., Attending Radiologist, Jewish Hospital and Israel Zion Hospital, *and* BERNARD S. EPSTEIN, M.D., Assistant Radiologist, Jewish Hospital, *Brooklyn, New York*

ALTHOUGH chronic recurrent intussusception of the large bowel is uncommon, it must be considered in the differential diagnosis of obscure intra-abdominal conditions. The writers have had the opportunity of observing eight cases diagnosed radiographically and confirmed by operation. Each patient was examined by means of a barium meal from above, as well as by opaque enemas, post-enema radiograms, and barium-air contrast enema radiograms. Repeated examinations were made in several instances. The post-evacuation and barium-air contrast enema studies were so helpful in establishing the diagnosis that we now regard them as indispensable.

Seven patients had cecocolic intussusception secondary to cecal tumors. In these cases, the ileum also intussuscepted. Pathologic examination revealed five adenocarcinomas and two leiomyosarcomas. The eighth patient had a colocolic invagination associated with a pedunculated leiomyosarcoma arising from the hepatic flexure.

The association of chronic large bowel intussusception with leiomyosarcoma is unusual. We have been unable to find reports of similar cases in the available literature.

Symptomatology.—The clinical picture of the seven patients with ileocecocolic intussusception was essentially the same. All complained of more or less persistent pain in the right lower quadrant, radiating to the epigastric and substernal regions. The pain varied considerably in intensity at different times. Nausea and anorexia were frequent. Vomiting and bloody stools were often observed. There were relatively long intervals of freedom between the acute episodes, and cathartics on occasion aggravated the symptoms. The history presented by the patient with colocolic invagination was somewhat more acute, only one attack of persistent right upper quadrant pain occurring before surgical intervention.

The chronicity of the symptoms, repeated subacute episodes, and the changing radiographic findings are in contrast with the syndrome usually observed in the acute forms of intussusception.

The relationship between the size of the intussuscipiens and intussusceptum no doubt plays an important rôle in the severity of the symptoms. In this connection Ehnmark (1) recalls that the large and small bowel of children are approximately the same size, whereas the large bowel of an adult is about three times as large as the small. Hence an intussusception in an adult involving the presence of ileum within the large bowel may be expected to produce symptoms of less severity than a colocolic invagination. This is supported by the findings in the cases here reported, in which the patients with ileocecocolic invagination had relatively chronic courses while the patient with colocolic invagination had but one attack before operation. In the latter case, it is possible that the presence of a long pedicle attached to the tumor mass helped produce more acute symptoms inasmuch as the constriction of the bowel about the pedicle prevented recession of the intussusception.

In the patients with ileocecocolic intussusception, the principal finding was a soft doughy tender mass in the right abdomen unaccompanied by rigidity.

In the case with colocolic invagination, starting at the hepatic flexure, the mass was palpated in the epigastrium. In most in-

[1] This is one of a series of papers contributed by friends and former pupils of I. Seth Hirsch, M.D.

stances, the tumor possesses spontaneous and passive mobility except when fixation occurs as a result of peritoneal reaction. In these cases, abdominal rigidity is usually present. The mass disappears with release of the intussusception, only to reappear with a recurrence.

Radiology.—The radiographic diagnosis of recurrent intussusception was first made by Snow and Clinton (2), in 1913. Frequent reports since have stressed the radiographic appearance (3, 4, 5, 6), as well as the therapeutic possibilities offered by barium clysmas (7, 8). Recently, Medo (9) published illustrations of various configurations resulting from invagination of the large bowel.

A consideration of the anatomy of intussusception is essential to the understanding of the radiographic picture. There is no single pathognomonic sign, the roentgenographic appearance varying with the degree and location of the intussusception at the time the examination is made. If the intussusception is sufficiently large, it may block the progress of the barium completely. Lesser degrees of obstruction may cause the barium to be trapped in the rugal folds, resulting in a wide range of roentgenographic patterns.

The anatomic changes produced by the intussusception may result in ballooning of the bowel proximal to the obstruction, into which the barium clysma may be unable to enter; or the barium may trickle through, string-like, into the distended arm. In other instances, the advancing head of the intussusceptum may partially obstruct the barium stream, producing configurations which have been referred to as "pincer-like," "beak-like," "cupola-like," "spiral," or other descriptive terms. (The composite finding of several examinations is more suggestive than any single observation.) No annular constriction nor worm-eaten irregularity such as is often observed with infiltrating neoplasms of the large bowel is present.

The barium-air contrast studies often portray a tumor by curvilinear barium markings in relief against the air-distended bowel. The tumor mass is thus often seen in silhouette sparsely covered and streaked with barium as it rests within the crevices of the neoplasm.

Fig. 1. Case 1. Post-enema air inflation study showing cecal tumor with characteristic curvilinear striations independent of normal haustral markings.

Case Reports.—Case 1. L. F., a 58-year-old white housewife, complained of vague abdominal pains above the right ilium for several years. The pains had increased in severity during the three weeks previous to admission, were intermittent, non-radiating in character, and varied considerably in intensity. Gradual loss of weight had been noted. About ten days before admission, the patient had had an acute attack of right lower quadrant pain "after eating prunes," which lasted several hours. There was no nausea or vomiting.

Physical examination revealed an oval tender mass in the right abdomen at the level of the iliac crest. There was no abdominal rigidity; visible peristalsis was present. On successive occasions the mass appeared and disappeared. Examination of the stool revealed the presence of occult blood.

Radiographic examination of the large bowel by means of a barium enema was not conclusive. Air inflation, after the

evacuation of the enema, clearly revealed the presence of a cecal tumefaction. The radiographic appearance of the ascending colon varied at successive examinations.

Fig. 2-*A* (*upper left*). Case 2. Barium enema demonstrating concentric striated defect of cecum fusing with the hepatic flexure due to partial intussusception.
Fig. 2-*B* (*upper right*). Case 2. Contrast enema study demonstrating reduction of incomplete intussusception by air pressure, and clear visualization of the tumor in the cecum with classical defects.
Fig. 3-*A* (*lower left*). Case 3. Post-enema study demonstrating intussuscepted tumor mass in the hepatic flexure.
Fig. 3-*B* (*lower right*). Case 3. Barium enema eight days later demonstrating tumor in the cecum with the intussusception spontaneously reduced. At operation the intussusception was found to have recurred.

At operation, a mass extending from the middle of the ascending colon to the hepatic flexure was found. The tumor was bluish in color and contained an invaginated section of ileum which could not be reduced. The patient died the following day.

An autopsy, a fungating cauliflower-like mass was found in the cecum, extending to and involving the ileocecal valve. Histologic examination of the mass revealed adenocarcinoma.

Case 2. B. J., 30-year-old male, complained of persistent right lower quadrant pain, marked anorexia, and vomiting for seven weeks. Pains occurred from two to eight times daily and lasted but a few seconds. The symptoms had appeared gradually and varied considerably in intensity. Some relief had been obtained from bicarbonate of soda. There was no febrile reaction. The patient had lost 35 pounds in weight in six weeks before hospitalization. Blood had been noted in the stool.

Physical examination revealed a moderately tender mass deep in the right lower quadrant, which did not change in size during the pre-operative period of observation. There was no abdominal rigidity.

A barium enema revealed shortening of the ascending colon and an obliteration of the angle of the hepatic flexure. A filling-defect was present in the cecal region. An air-contrast radiograph definitely showed cecal tumefaction.

At operation, an intussusception of the cecum and ascending colon into the transverse colon was demonstrated. A cauliflower-like growth about six centimeters in diameter, arising from a short pedicle, was present in the cecum. The mass was soft to the touch and worm-like in appearance. The intussusception was reduced and the tumor excised.

Histologic examination of the specimen revealed a leiomyosarcoma. The pathologist's description is as follows: "The mucosal lining of the papillary structures show very marked hyperplasia of the mucous glands. No evidence of invasive changes of any epithelial elements is noted. The connective tissue and muscular coats show marked proliferative changes, and at the base of the pedicle of each of the papillary masses may be found large spindle-shaped cells, the nuclei of which show marked activity and in general fulfill the criteria for malignant change. Most of the spindle-shaped cells can be definitely seen arising from the muscular layer."

Case 3. L. F., a 59-year-old housewife, complained of intermittent colicky pain in the right lower quadrant, radiating to the epigastrium and substernal regions. Episodes of this character had occurred infrequently for about two years. They had increased in frequency during the six weeks previous to admission to the hospital. The onset of pain was gradual, and on occasion followed a cathartic. Attacks were often preceded by diarrhea and bloody stools. Anorexia was present, and there had been considerable loss of weight.

Physical examination revealed a soft doughy mass in the right lower quadrant which appeared and disappeared on different occasions. No abdominal tenderness, rigidity, or visible peristalsis was present.

A barium enema revealed a dome-shaped obstruction at the hepatic flexure with a large gas defect distal thereto, through which some barium trickled, visualizing false cecal rugal markings. An immediate post-enema study clearly portrayed a mass in the proximal portion of the transverse colon. A barium enema one week later readily revealed cecal tumefaction, and the barium-air contrast radiograph more clearly outlined the tumor.

At operation about one month later, an ileocecocolic intussusception was found due to a sessile mass in the cecum which involved the lower lip of the ileocecal valve. Pathological report was that of adenocarcinoma.

Case 4. S. R., a 48-year-old male, complained of persistent dull-aching right lower quadrant pain, varying in intensity for six weeks. Tarry stools had been present on several occasions. There was no loss of weight, anorexia, vomiting, nor fever.

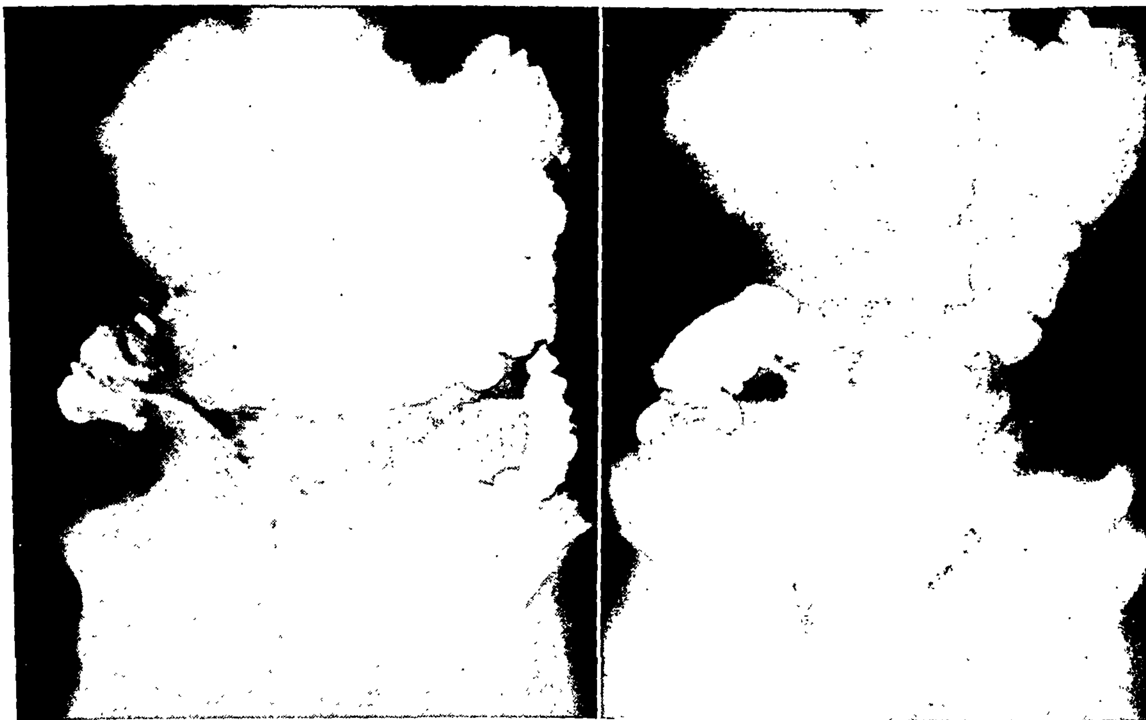

Fig. 4-*A* (*upper left*). Case 4. Twenty-four-hour barium meal study demonstrating defect just beyond the hepatic flexure, associated with localized gaseous distention.

Fig. 4-*B* (*upper right*). Case 4. Post-enema study showing deformity now in cecal region. The filling-defect at the hepatic flexure is no longer present.

Fig. 5-*A* (*lower left*). Case 5. Twenty-four-hour study showing barium meal trapped in ascending colon, with marked distention.

Fig. 5-*B* (*lower right*). Case 5. Barium-air contrast enema six days later still showing barium trapped in ascending colon. Hiatus in transverse arm due to intussuscepted bowel with intraluminal neoplasm beyond. Note characteristic concentric striations.

Physical examination revealed tenderness in the right lower quadrant. Some resistance to deep palpation was noted but no true abdominal rigidity. A questionable mass at times was palpated.

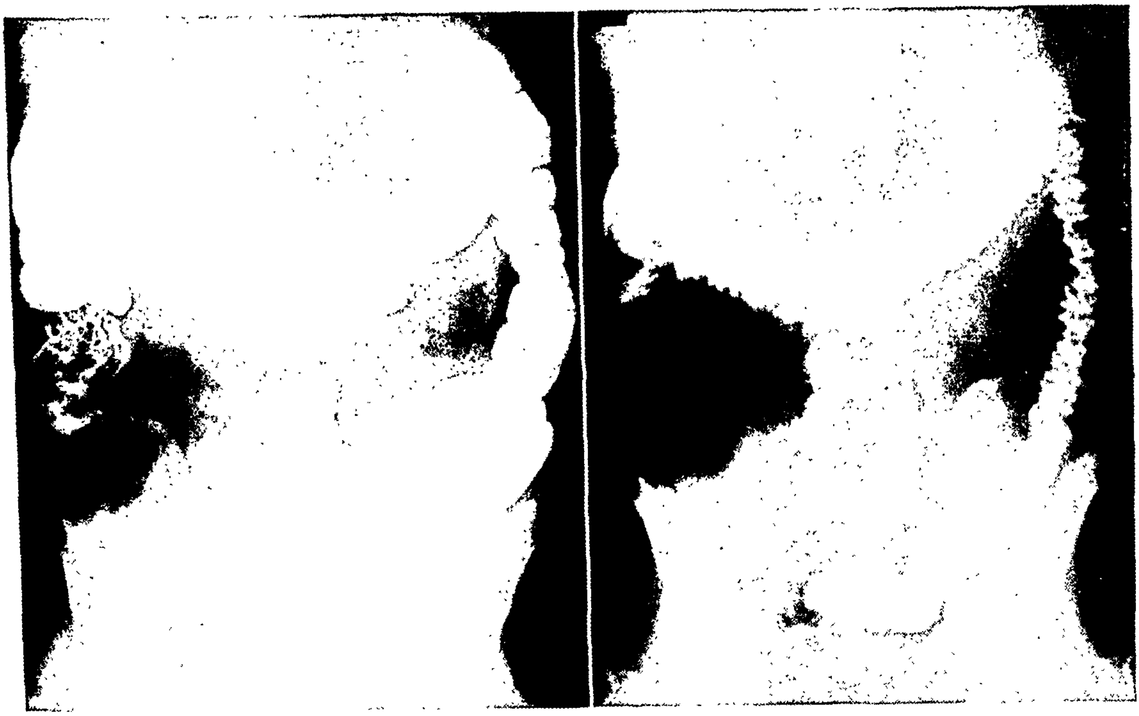

Fig. 6-*A*. Fig. 6-*B*.

Fig. 6-*A*. Case 6. Barium enema showing filling-defect in cecum with honey-comb markings as the barium dips into the tumor crevices.

Fig. 6-*B*. Case 6. Post-enema filling showed intussuscepted tumor mass at the hepatic flexure.

X-ray examination 24 hours after a barium meal revealed elevation of the cecum, with a filling-defect in the hepatic flexure distally. A barium enema flowed freely from rectum to cecum. After evacuation of the enema, however, a cupola-like deformity was present proximal to the hepatic flexure, with distortion of the normal cecal contour.

At operation, a sessile mass about eight centimeters in diameter was found in the cecum. The ileocecal valve was involved. It apparently had been intussuscepted and reduced spontaneously previous to operation. Histologic examination of the specimen revealed adenocarcinoma.

Case 5. M. A., a 55-year-old housewife, complained of pain in the right upper quadrant after taking a cathartic. The pain eased within a few hours, then returned and persisted for two weeks. No similar episodes had occurred previously. A tarry stool was noted for the first time a month before admission to the hospital. There was evident loss of weight. No anorexia, vomiting, nor diarrhea had been noted.

Physical examination revealed a very tender large nodular mass in the epigastric and umbilical regions. The tumor was constant and did not vary in size.

A film taken 24 hours after a barium meal revealed the barium trapped in the ascending colon, which was markedly distended. The barium remained there for six days. An enema then administered flowed to the hepatic flexure, but not beyond. A post-enema air-barium contrast radiograph brought the mucosal markings of the transverse and descending arms into relief. Some barium appeared to have reached the ascending colon. The marked irregularity adjacent to the obstruction was

interpreted as evidence of intrinsic pathology. A hiatus in the transverse colon was present on all films.

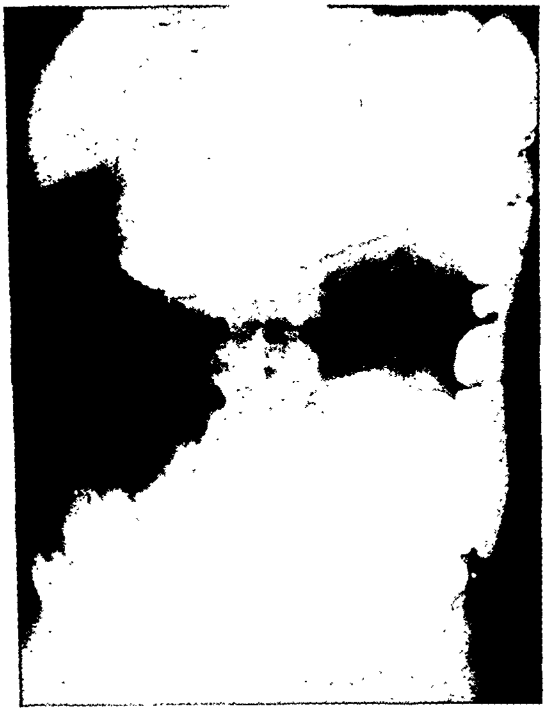

Fig. 7. Case 7. Intussusception arising from perforating carcinoma at hepatic flexure. Adjacent duodenum was involved and peritoneal implants were present. A contrast enema would probably have visualized the tumor more clearly.

At operation, an intussusception of the hepatic flexure into the transverse colon was found. A polyp about five centimeters in diameter arising from a long slender stalk in the hepatic flexure was the head of the intussusception. The invagination was reduced and the polyp removed. Histologic examination of the polyp revealed a leiomyosarcoma.

Case 6. D. R., a 42-year-old male, was admitted to the hospital complaining of having had intermittent abdominal cramps, diarrhea, and bloody stools for nine months. The onset had been gradual, usually occurring one or two hours after meals. At first cramps were generalized and later were located in the right lower quadrant. There were no chills nor temperature. Bright red blood was first noted in the stool three months before admission; tarry stools likewise were noted. There was no constipation. The patient had lost 16 pounds in weight since the onset of symptoms.

On physical examination some tenderness was noted in the lower quadrants along the ascending arm and sigmoid. No mass could be palpated.

X-ray examination by means of a barium enema revealed a filling-defect in the cecal region. The caput rested at the iliac crest. The rugal markings of the cecum were bizarre and stood out in relief against the filled bowel, separated from it by a definite line of demarcation. After evacuation of the enema, the cecum still remained elevated.

At operation, a hard indurated mass was found in the cecum, and about four inches of intussuscepted ileum was present. Histologic examination of a biopsy specimen revealed a papillary colloid adenocarcinoma.

Case 7. L. W., a 50-year-old male, complained of abdominal pains and progressive weakness for the past four months. Rectal bleeding at times was attributed to hemorrhoids (?), although a hemorrhoidectomy had been performed two years previously. Diarrhea was present for four days prior to admission. The patient vomited on two occasions. His temperature was from 101 to 102°. There was belching, nausea, and peri-umbilical distress. Physical examination of abdomen was negative. Blood count revealed: red blood cells, 3,200,000; hemoglobin, 40 per cent; white blood cells, 5,900. The urine was negative.

A barium enema disclosed an obstruction at the hepatic flexure, with telescoping of the cecum and ascending arm into the transverse colon.

Operation revealed a mass at the hepatic flexure, fixed posteriorly, produced by an intussusception of the cecum and ascending colon into the hepatic flexure and adjacent portion of the transverse arm. The mass was adherent to the duodenum, which presented carcinomatous implants on its serosa. Surrounding exudate was pres-

ent. Following reduction, a bulky tumor mass was found in the cecum.

Pathologic diagnosis was: ulcerated adenocarcinoma of cecum, with perforation and localized abscess formation.

Though the x-ray in this case was diagnostic, the tumor mass itself was not demonstrated. It is our belief that had a contrast enema been given, in addition to the intussusception, the tumor mass would have been visualized.

Case 8. D. K., a female 57 years of age, suffered from recurrent febrile reactions, ranging from 100 to 103° for the past several weeks. There was general weakness and constipation so that daily enemas were employed. Three days previous to admission, there was transient epigastric distress but no vomiting. Her appetite was fair at times only. Mucus and blood were found in a diarrheal stool nine days after admission. From this time on, blood was found on repeated occasions. There was no palpable mass, distention, nor abdominal rigidity. Slight tenderness on the right side of the abdomen was present at times.

A barium clysma flowed freely through the bowel to the hepatic flexure where it met with an obstruction. The ascending arm was not successfully outlined and no tumor mass was demonstrated. Intussusception was suggested from the barium contrast enema skiagram, which revealed a large irregular tumor mass at the hepatic flexure. The deformity from the tumor itself was characteristic—a negative, somewhat globular defect, with curvilinear barium striations throughout, in a grossly distended bowel.

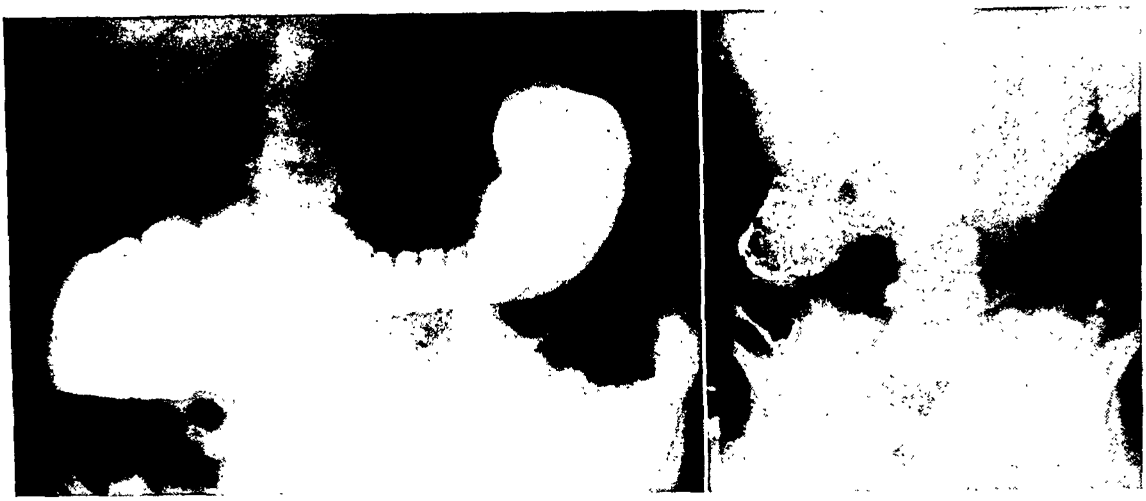

Fig. 8-*A*. Fig. 8-*B*.

Fig. 8-*A*. Case 8. Barium enema. Ileocecal intussusception from cecal tumor. Note dilatation of bowel embracing the intussusceptum. Cecum telescoped and not visible.

Fig. 8-*B*. Case 8. Contrast enema study demonstrating large intussuscepted tumor at the hepatic flexure. The intussusception has reduced partially following the procedure.

Operation revealed a mass at the hepatic flexure consisting of intussuscepted terminal ileum and cecum. After reduction, which was relatively easy, a palpable sessile mass, about three centimeters in size, was found in the cecum. The pathologic report was a circumscribed papillomatous tumor which, on section, proved to be a leiomyosarcoma.

CONCLUSIONS

1. Eight cases of chronic intussusception of the large bowel in adults are reported.
2. Subacute episodes, with varying intervals of quiescence, are the rule.
3. Repeated x-ray examinations of the colon are important in diagnosis.

4. Post-evacuation radiographs and barium-air contrast enemas have proved the most valuable methods of study in our hands.

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THE ANATOMICAL POSITION OF THE ILEUM IN HEALTH AND DISEASE[1]

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IT IS NOW almost six years since the attention of the medical world was attracted to the subject of regional or, more often, terminal ileitis. In that short space of time, the full clinical picture has been identified, the etiology discussed, the complications noted, and the surgical therapy amply instituted.

The fact that any part or segment of the ileum might be, and often is, involved, and the recognition of participation of higher sites in the jejunum have led to the name "regional enteritis." Yet for practical purposes the main brunt of the disease, and by far its most common form, is not a general enteritis, but a terminal ileitis, the last six to twelve inches of ileum being exclusively involved in over 90 per cent of all cases.

In addition, a common complication of fistula formation frequently characterizes the disease, these fistulous tracts making their terminus in the lower right anterior abdominal wall or traversing the pelvis to appear in the perineum as perirectal or recto-vaginal fistulas.

If one were to ask an anatomist, an internist, a surgeon, or even a radiologist the normal position and site of the terminal segment of the ileum, the answer would likely be hesitant, if a correct one, and would probably be based more on a general impression than upon accurate knowledge or observation.

The sparsity of accurate data regarding the true anatomical position of the terminal ileum and the study of these low fistulous complications have together led us to attempt to ascertain the exact position of the terminal loop of ileum and its anatomical relationship, both in the normal body and when it is the object of a disease process.

Anatomical and Embryological.—References to the exact position of the terminal ileum are sparse in anatomical textbooks and practically missing from current literature. Very few anatomists mention the subject at all; those who do—Testut, Sernoff, Piersol—place the terminal ileum deep in the pelvic fossa on the right side, though exact observations or notations are brief and insufficient from a practical standpoint.

The exact anatomical location of the terminal ileum is dependent upon the normal embryological development of the ileocecum and its associated mesenteries. Ontogenetically, the ileocecum develops from that portion of the midgut which is caudad to the superior mesenteric artery, "the post-arterial segment" of Dott; according to Mall and to Huntington, the ileocecum is returned to the celomic body cavity from the physiological umbilical pouch during the tenth week of embryonal development. It assumes primarily an anterior position beneath the right lobe of the liver whence it descends to the normal adult position in the right iliac fossa. The mesentery of the ileum is formed by the fusion of the superior mesenteric artery to the posterior abdominal wall; this mesentery becomes, and is, continuous with the mesentery of the ascending colon. Both of these processes are usually effected before parturition but they may be delayed until after birth.

According to Alglave, the cecum fails to descend, remaining high under the liver in almost 3 per cent of all cases. On the other hand, it may descend to the other extreme, that is, below the true pelvic brim in about 10 per cent of 1,050 specimens studied by G. M. Smith. In this latter series, the cecum and presumably the terminal ileum were found resting on the

[1] This is one of a series of papers contributed by friends and former pupils of I. Seth Hirsch, M.D.

4. Post-evacuation radiographs and barium-air contrast enemas have proved the most valuable methods of study in our hands.

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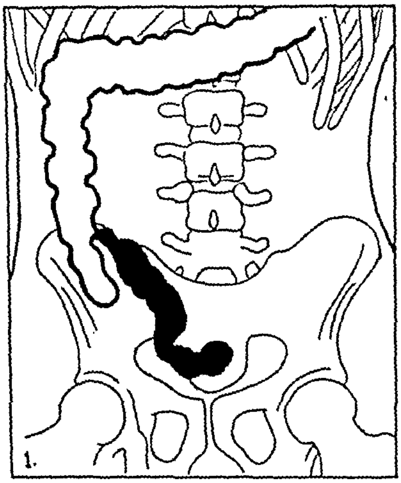
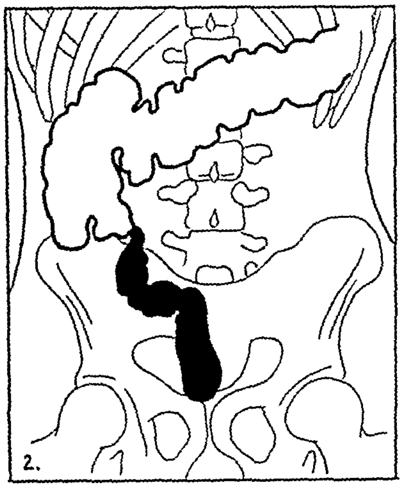
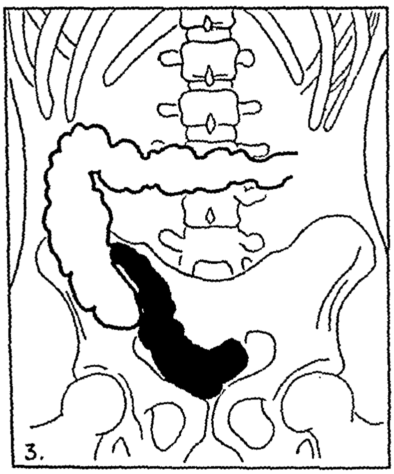


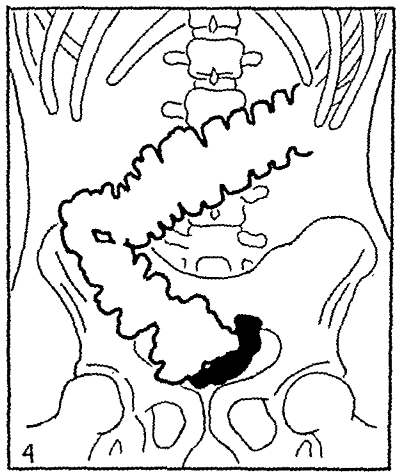
Usual position of cecum + ileum



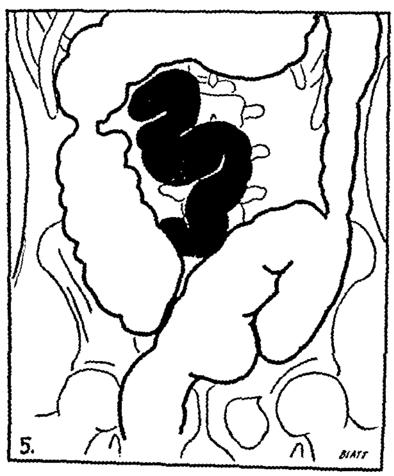
High cecum-ileum to pelvis



Low cecum-high medial implantation of ileum



Complete descent-cecum + ileum in pelvis



Exceptional position of terminal ileum-abrupt ascension

NORMAL TERMINAL ILEUM – ANATOMICAL POSITIONS

Plate 1.

pelvic cavity. The splenic flexure was situated at the level of the iliac crest.

The course and site of the terminal ileum was well visualized in these 150 cases. In 72 per cent, the terminal segment of the ileum arose from the cavity of the true pelvis, where it lay on the floor of the pelvis, to ascend and join the medial aspect of the cecum in the right iliac fossa (Fig. 1, Plate 1). When the cecum rides high, the course of the terminal ileum is the same but the ascent is greater (Fig. 2, Plate 1). In the instances of low implantation of the cecum, where its tip dips into the true pelvis, the course of the ileum is more circuitous, the ileum curving around the medial aspect of the cecum to a rather high implantation at the ileocecal junction (Fig. 3, Plate 1).

TABLE I.—JUNCTION OF TERMINAL ILEUM AND CECUM

Vertebral Body	Case Incidence
4th lumbar	3
5th lumbar	9
5th lumbar to 1st sacral	17
1st sacral	58
1st and 2nd sacral	32
2nd sacral	2
3rd sacral	1
In pelvis	28
Total	150

In 26 per cent of the cases, the cecum was well within the true pelvic cavity. In these instances, the entire terminal loop of the ileum as well as the ileocecal junction appeared to lie directly on the pelvic floor (constituted by the levator ani muscles, Fig. 4, Plate 1). In only three cases (2 per cent), the terminal segment of the ileum was not at all in the pelvis but arose high from its junction with the cecum, passed transversely for from one to two inches, and was then directed upward toward the transverse colon. This unusual direction was demonstrated by both meal and enema methods. The loop could not be depressed nor its position changed by manual pressure under fluoroscopic control (Fig. 5, Plate 1).

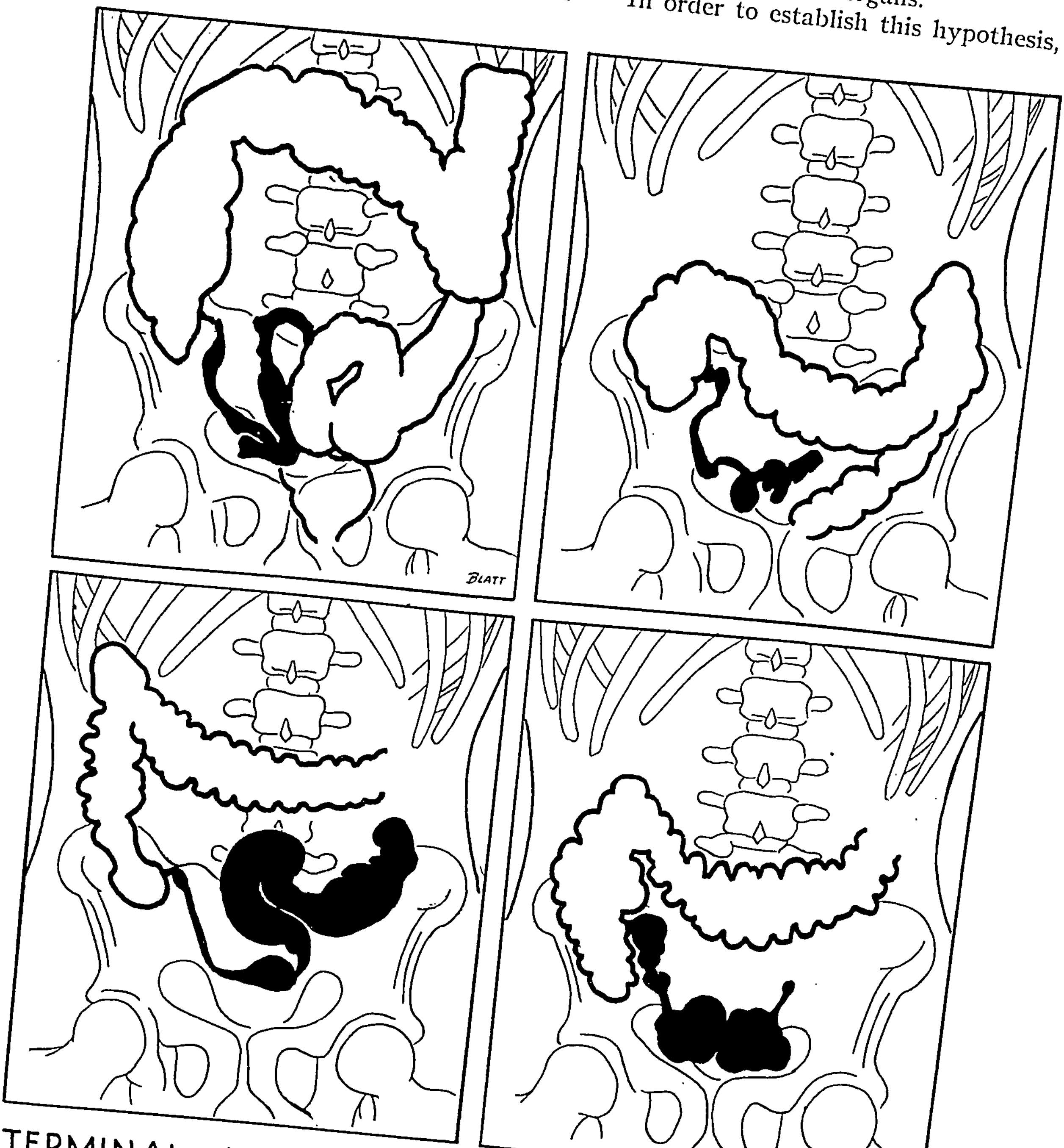
Pathological Ileum.—The plates of 25 cases of "terminal ileitis" were studied for the position of the diseased segment. In all of these instances, the pathological terminal loop lay within the true pelvis; in fact, on the floor of the pelvic cavity, its course as in the normal control cases, upward to its entrance at the ileocecal junction. This course and site is practically uniform. In the diseased instances, the ileocecal junction is regularly at or below the level of the first sacral vertebra (usually fixed by adhesions) and the terminal inches of the ileum descend directly to the pelvic floor.

In one instance, the diseased segment made a short horizontal course and then descended into the pelvis; in another case with more extensive involvement of the whole ileum, the diseased loop was seen to descend to the floor of the true pelvis and then to rise out of the pelvis toward the left mid-abdomen. This latter course is true of all cases of segmental enteritis in which more than the terminal loop is affected; here the more proximal diseased areas occupy the lower, mid-, or right abdomen, ascending as the process extends toward the left, mid-, or upper abdomen.

In several instances, we have true and accurate surgical descriptions of the site and position of the diseased terminal ileum in which the terminal segment was found to be in the true pelvis. The entire pelvis was found to be occupied by a mass of matted small intestine, usually adherent to the peritoneal reflexion over the sacrum, to the base of the bladder, or to the sigmoid by firm dense adhesions. Occasionally even the tip of the omentum was found to be in the pelvis adhering to and covering the diseased segment. In one accurate description by an observing surgeon, it is stated that the cecum was bound down and fixed by an inflammatory exudate arising from the ileum. The terminal ileum descended from its fixed point of attachment to the cecum, extending abruptly downward into the cul-de-sac behind the uterus and adherent to the anterior rectal wall. The diseased ileum was not removed; four months later the patient developed a fecal recto-vaginal fistula.

Remarks.—In 15 per cent of our observed clinical cases of ileitis, we have noted perineal fistulas (perirectal, perineal, or rectovaginal) as a complicating factor. In several of these cases (Penner and Crohn), we had reason to believe that a direct fistulous tract made its course from the diseased loop of ileum lying on the floor of the true pelvis, seeping downward through the fascial planes to make its exit somewhere on the perineum between the rectum and the vagina and involving either one or both of these organs.

In order to establish this hypothesis, it



TERMINAL ILEITIS - ANATOMICAL POSITIONS

Plate 2.

was necessary to determine the true position of the terminal ileum, first in health, and then when diseased.

The above study confirms these ideas, insofar as it is shown that both in health and under pathological conditions the terminal ileal segments lie almost uniformly on the pelvic floor in direct contact with the peritoneal reflexion and fascial planes covering the levator ani suspensory muscles.

This position of the normal and diseased terminal ileum as described by those few anatomists who have made actual notations, has been confirmed by routine roentgenography and has been transcribed in detail by observing surgeons. The findings rationalize the clinical observations of fistulous perineal tracts emanating from the low-lying ileum and making their exit by gravity and by following fascial planes of cleavage onto the perineal floor.

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X-RAY THERAPY IN THE TREATMENT OF ACUTE PNEUMONIA[1]

REPORT COVERING THE USE OF X-RAY THERAPY IN THE TREATMENT OF PNEUMONIA AT THE NIAGARA FALLS MEMORIAL HOSPITAL, FROM OCT. 1, 1937, TO SEPT. 30, 1938

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THE presentation by Eugene V. Powell, M.D., of Temple, Texas, of his paper entitled "Roentgen Rays in the Treatment of Acute Pneumonia" at the Fifth International Congress of Radiology, in Chicago, September, 1937, brought to our attention a use for x-ray therapy which, up to that time, had been almost entirely neglected. Subsequent publications by this author should be reviewed by those interested in the pneumonia problem (1,2).

This neglect of x-ray therapy in such a definitely acute infectious condition as pneumonia seems strange, in retrospect, to radiologists and to other physicians who may be familiar with the value of x-ray therapy in acute infections when we think of the advances in the use of x-ray therapy in the past 35 years.

The use of x-ray therapy in the treatment of boils, carbuncles, erysipelas, cellulitis, gas infection, otitis, mastoiditis, breast abscess, adenitis, parotitis, phlegmon, onychia and paronychia, gonorrheal arthritis, and other infectious conditions may be said to have gone far beyond the experimental stage.

The report here offered is chiefly a summary of 138 cases of pneumonia which passed through the X-ray Department of the Niagara Falls Memorial Hospital during one year, Oct. 1, 1937, to Sept. 30, 1938, inclusive, together with other material from the hospital records and other sources. The writer attempts to draw conclusions from those cases that were radiographed and/or treated in the X-ray Department of the hospital during the twelve-month period that x-ray therapy was used in the treatment of acute pneumonia. For the purposes of this paper, only those pneumonia cases that were treated and/or radiographed are analyzed extensively, but there were others that were not radiographed, for one reason or another. These also are included in several of the tables, in order to be as accurate as possible and to secure a control group.

To quote from a personal letter from Alexander D. Langmuir, M.D., Medical Consultant of the Bureau of Pneumonia Control, of the Department of Health of the State of New York, under date of Dec. 15, 1938: "Reliable statistics to make fair comparisons are very difficult to obtain, because of the tremendous number of variables which are always operating."

It is with full cognizance of the truth of this statement that this report is offered. It is hoped that the material herein contained will not engender, in those who may happen to have it come to their attention, that unwarranted enthusiasm which too often is accorded a somewhat new development in medical fields. Also, it should not be passed over too lightly, as being overrated, by those who are "sold" on other methods of treatment. Until sufficient data by others working on the subject may be presented to the medical profession, confirming or negating the apparent results secured to date, it would seem to us that there is a definite field for this use of x-ray therapy.

In attempting this evaluation of the use of x-ray therapy in pneumonia, it was felt that not only was the total death rate of the patients of interest, but that also the cost of the disease as indicated by the length

[1] This is one of a series of papers contributed by friends and former pupils of I. Seth Hirsch, M.D.

of hospitalization, etc., was of importance. Our records, we believe, bring out figures to show that the use of x-ray therapy in acute pneumonia has a very definite influence in decreasing the cost of pneumonia cases. In any disease, any method of therapy which reduces the death rate, the length of hospitalization, and the cost to the patient deserves consideration by physicians in general.

"Pneumonia is essentially a disease of winter and early spring. The four months from January through April include about 75 per cent of the cases in any normal year.

"In New York State, pneumonia in its various forms causes a greater loss of life than any other communicable disease and is exceeded as a cause of death only by heart disease and cancer. While these two latter are diseases, for the most part, of late life, pneumonia takes about 50 per cent of its toll during the ages of greatest usefulness. The annual loss of life from this cause in New York State is about 12,000" (3). (In the adjacent Province of Ontario there are about 2,500 deaths per year.)

Desjardins (5) says: "The death rate gives us at least an approximation of the incidence of the disease, since the case fatality rate, in lobar pneumonia at least, is quite constantly 25 per cent. Thus the pneumonia incidence rate is about four times the death rate." Therefore, we may justly estimate that in New York and Ontario there may be approximately 58,000 cases of pneumonia each year. If we estimate the cost of a case of pneumonia—taken care of outside the hospital—as only fifty dollars, and many cases will far exceed that figure, we have nearly three million dollars, probably much more, as the cost of pneumonia per year in the State of New York and the Province of Ontario. When we consider that the cost of pneumonia serum alone, where it is not supplied by the state or province, will be around one hundred dollars per case, and then also consider the loss of working time of those who are sick, the added expense to the families, etc., a figure of ten million dollars, or more, may more accurately give the picture of the financial side of the pneumonia problem. As many cases require hospitalization, special nursing, etc., for an extended period of time, due to complications, we believe that our figures may prove of interest. Of course, not all cases require hospitalization, and, as already stated, reliable statistics are difficult to obtain, therefore, the above figures may require revision either upward or downward.

Quoting from Powell (1): "The *modus*

TABLE I.—GENERAL CLASSIFICATION

Bronchopneumonia

	Under 10 yrs.		10–20 yrs.		20–30 yrs.		30–40 yrs.		40–50 yrs.		50–60 yrs.		60–70 yrs.		Over 70 yrs.	
	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.
Rec.	2	3		1							2	1		1	3	1
Died	15	22	3		2	3		1	1	1	1	2	1			

Lobar Pneumonia

	Under 10 yrs.		10–20 yrs.		20–30 yrs.		30–40 yrs.		40–50 yrs.		50–60 yrs.		60–70 yrs.		Over 70 yrs.	
	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.
Rec.	22	11	7	4	6	1	7	1	4	4	5	1		1	1	1
Died	4		1		1	3	1	1	4	1	4	3	4	2	1	

Shows general classification of the 172 cases of pneumonia admitted to the hospital from Oct. 1, 1937, to Sept. 30, 1938. The cases are divided into broncho- and lobar, and the Table also shows recoveries and deaths, by decades, for males and females.

operandi of radiation therapy in this and other acute infections is still unexplained. There seems to be definitely some relation between the destruction of the infiltrating leukocytes and the resolution of the inflammatory condition. It may be an increased permeability of the tissues and perhaps of the infecting organisms themselves to the natural lysins or ferments. The prompt response of the Type III cases suggests that either the capsule is dissolved or at least made more permeable to the action of the immune substances."

Smillie (4) says: "The rate at which the varieties of leukocytes mentioned are destroyed by irradiation under experimental conditions corresponds closely to the rate at which acute inflammations subside after exposure to a suitable dose of roentgen rays or radium." And further, "As a result of the disintegration of infiltrating leukocytes the antibodies, ferments, and other protective substances which these cells contained are liberated into the surrounding spaces where they become mixed with the tissue fluids and become available for defensive purposes." Results from the x-ray treatment of acute inflammatory processes seem to prove that the response to irradiation is in proportion to the degree of leukocytic infiltration.

The aforestated opinions seem to be the most reasonable explanations of the results secured by the use of x-ray therapy in acute infections that the writer has noted in the literature.

In this study of pneumonia, no case has been refused x-ray therapy when it was requested by the attending physician, even though the writer considered it as useless. The sooner x-ray therapy was used after diagnosis, the better have been the results, as reported by others, and the same is true in this series. In this series, treatments have been given to patients who were practically moribund at the time, just because it was requested. Whenever possible, the patient underwent his x-ray treatment immediately after admission to the hospital, and before being taken to his room.

The films in many of these cases are not

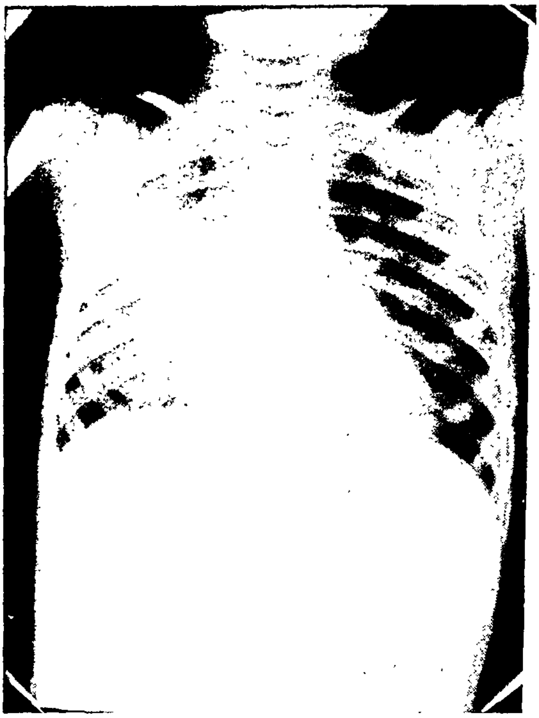

Fig. 1. Case 1. Roentgenogram of F. V. L., female, aged three, lobar pneumonia. Film made Sept. 25, 1937, four days after entering hospital, about ten days after onset of illness. Greater portion of right middle lung-field consolidated; no specific type of sputum demonstrated. X-ray therapy with bedside unit began day after this film was made. (See Chart 1.)

as brilliant as might be desired. It must be remembered that all of these patients were acutely ill, and in order to disturb the patient as little as possible, only his outer garments were removed. Then a cassette was slipped under his back and a film made, usually at 36-inch target-film distance, 30 ma., and one-tenth second exposure, varying the kilovoltage to suit the thickness of the patient. After development and study of the film, the patient was taken to the therapy set-up in the next room and, without disturbing him at all, was given x-ray therapy. The factors used in this series were: 75 kv., 3 mm. aluminum filter, 200 r units, using an open lead glass bowl type of tube holder with a 15 cm. opening, cen-

tering over the area of chief consolidation but without using a cone or other method of screening off the rest of the chest. In bronchopneumonia, the therapy was usually centered over the area which showed most confluence of mottling, but without excluding the entire chest. The kilovoltage used in our series has not been as high as that suggested by Powell, who, at the last reports, was using 140 kv. As the cases treated were handled entirely on an experimental basis, and in most cases only a single anteroposterior film in the supine position was made, rather than a

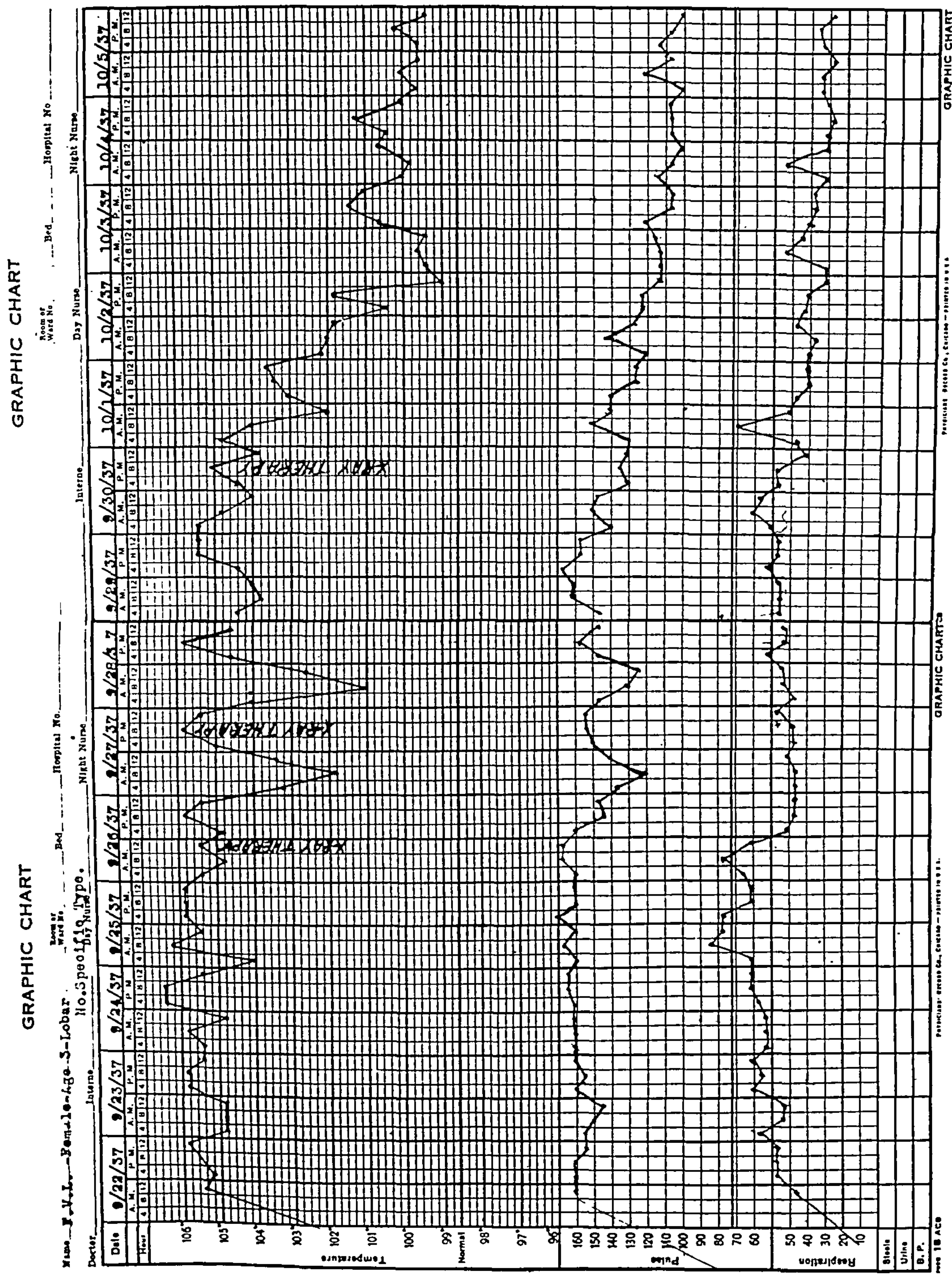

Chart 1. Case 1. Graphic chart of F. V. L. Note that respirations dropped from 75 to 45 per minute after first x-ray treatment and did not go up again; the pulse rate dropped at the same time as the temperature. Note the immediate drop in temperature after each x-ray treatment.

TABLE II.—CONSOLIDATED GENERAL CLASSIFICATION OF 172 CASES OF PNEUMONIA

Total admitted to hospital from Oct. 1, 1937, to Sept. 30, 1938

	No. Cases	M.	F.	Deaths	
				M.	F.
Broncho-	66	30	36	7	5
Lobar	106	72	34	20	10
Total	172	102	70	27	15

Pneumonia death rate for same period

	Percentage
Pneumonia cases admitted—broncho- and lobar (172 cases—42 deaths)	23.8
Av. broncho- death rate (66 cases—12 deaths)	18.1
Av. male broncho- death rate (30 cases—7 deaths)	23.3
Av. female broncho- death rate (36 cases—5 deaths)	13.9
Av. lobar death rate (106 cases—30 deaths)	28.3
Av. male lobar death rate (72 cases—20 deaths)	27.7
Av. female lobar death rate (34 cases—10 deaths)	29.4
Av. pneumonia death rate—1935	30.8
Av. pneumonia death rate—1936	26.7
Av. pneumonia death rate—1937	32.1

TABLE III.—CONSOLIDATED GENERAL CLASSIFICATION OF 138 CASES REVIEWED

(This table includes only those cases radiographed and/or treated)

	No. Cases	M.	F.	Deaths	
				M.	F.
Broncho-	53	27	26	5	3
Lobar	85	59	26	12	7
Total	138	86	52	17	10

	Percentage
Av. pneumonia death rate for 138 cases reviewed—broncho- and lobar (138 cases—27 deaths)	19.5
Av. broncho- death rate (53 cases—8 deaths)	15.0
Av. male broncho- death rate (27 cases—5 deaths)	18.5
Av. female broncho- death rate (26 cases—3 deaths)	11.1
Av. lobar death rate (85 cases—19 deaths)	22.3
Av. male lobar death rate (59 cases—12 deaths)	20.0
Av. female lobar death rate (26 cases—7 deaths)	23.0

complete chest study, the location of consolidation was usually reported as extending between certain levels, rather than being described as involving any special lobe. It is an interesting point, perhaps, to know what lobe is involved, but there may be some question as to actually how valuable such information is to the attending physician after he gets it. If an abscess or other cause should develop later, further studies are made when, and if, necessary. It is felt by the writer that excessive handling by the physician in making his clinical examinations in some cases of pneumonia may do more harm than good, and, likewise, it would seem undesirable to disturb the patient in the x-ray department more than is absolutely necessary.

Sante (6) says: "Lobar pneumonia may be defined as an acute infectious respiratory disease characterized by dense consolidation of one or more lobes of the lung, presenting constitutional symptoms. It is caused by the pneumococcus (in about 96 per cent of the cases) which gains entrance to the lungs by way of the trachea and bronchi and spreads rapidly toward the periphery until it finally involves the entire area of the lung supplied by the bronchiole, through which the invasion originally occurred. Occasionally, however, especially in children, it would seem that the consolidation occurs first in the periphery of the lung. In the stage of hilum consolidation within the first 24 hours of the disease, lobar pneumonia cannot be differentiated roentgenographically from acute respiratory infections such as hilum pneumonia, primary acute lung abscess, and beginning caseous tuberculous pneumonia. Within 24 hours, however, lobar pneumonic consolidation . . ." usually spreads to involve an entire lobe, thus helping to differentiate it radiographically. Lobar pneumonia usually gives a history of an acute onset.

Quoting Karsner (7): "The disease rapidly reaches its acme or fastigium, which remains for a period usually of from

seven to eleven days, to be followed in half the cases by crisis, and in the other half by lysis; convalescence may be interrupted by a variety of complications."

Bronchopneumonia (or atypical pneumonia) is a pneumonic process characterized by multiple small areas of infiltration clustering about the bronchi, which follows direct extension through the bronchial wall of infection previously present in the bronchi (6). Thus it usually has a longer history of acute respiratory infection than is the case with lobar pneumonia. No specific organism has been found to be the cause of bronchopneumonia. The roentgenogram usually shows a number of soft infiltrations with a feathery border located about the bronchi of the lower lobe. The condition is almost always bilateral and usually only in the lower lobes. The patches may be irregularly distributed, usually poorly defined, varying in diameter from 5 to 15 mm. or larger. In bronchopneumonia, "The period of fastigium or acme is of irregular duration, sometimes being relatively short, and sometimes extremely prolonged. Crisis is unusual—most of the cases tending toward convalescence after a variable period of lysis" (7).

We also have another type of pneumonia not so frequently mentioned and often considered as one stage of lobar pneumonia, that is, hilum pneumonia. It probably is an atypical type of lobar pneumonia, as the clinical symptoms and course of the disease are very similar. The physical signs of true lobar pneumonia are, of course, lacking, because the consolidation remains confined to the hilus region. The recovery is usually by crisis.

In the present discussion, the cases have been divided into two types, broncho- and lobar, the hilum type being considered as lobar.

One hundred and thirty-eight charts of the Niagara Falls Memorial Hospital, out of the 172 pneumonia cases admitted, have been reviewed and the findings divided into 50 headings and numerous sub-headings. Those studied in detail include all the pneumonia cases passing through the X-ray Department, during the period under discussion. Needless to say, not all the headings and sub-headings can be included in this presentation, nor can all the findings be discussed.

The ages of these patients varied from three weeks to 76 years. (See Table I.)

The general classification, with special attention to death rates of the various types of pneumonia, during the period under discussion, is consolidated in Table II. Also in Table II are included death rates for the years 1935, 1936, 1937, which are seen to average nearly 30 per cent. Of course, in 1935, 1936, and 1937, many patients were radiographed, but none received x-ray therapy until the last three months of 1937. Study of the 138 cases treated and/or radiographed is consolidated into Table III.

It is interesting to note, comparing Table II with Table III, that the cases which passed through the X-ray Department had approximately a 4 per cent lower death rate than the general hospital pneumonia death rate for the 12 months under consideration, but the striking point in this tabulation is the very marked difference between the patients who were given x-ray therapy and/or radiographed for diagnosis, and those who did not visit the X-ray Department at all; that is, the difference between 19.5 and 44.1 per cent. This is shown in Table IV.

Eighty-six per cent of all the pneumonia patients in the hospital during the period of this study were at least radiographed, only 34 cases not being exposed to x-ray in any way. It must be admitted that it is perhaps unfair to compare figures on a group of 34 cases with the figures on 138 cases, but this is the only means we had for securing a control group figure, so these figures are offered for what they are worth. However, as the death rate in pneumonia has often been stated to run from 30 to 50 per cent, perhaps a figure of 44.1 per cent may not be so far out of line. It almost seems impossible that the use of x-ray

(in some cases only as a diagnostic agent) could account for this tremendous improvement in death rate. However, it is not so long ago that Granger startled us with his results in the treatment of otitis media and early mastoiditis, using dosages only equivalent to the amount of x-ray used in making two films. Then again, Powell (1) remarks on improvement in pneumonia cases as a result of fluoroscopy.

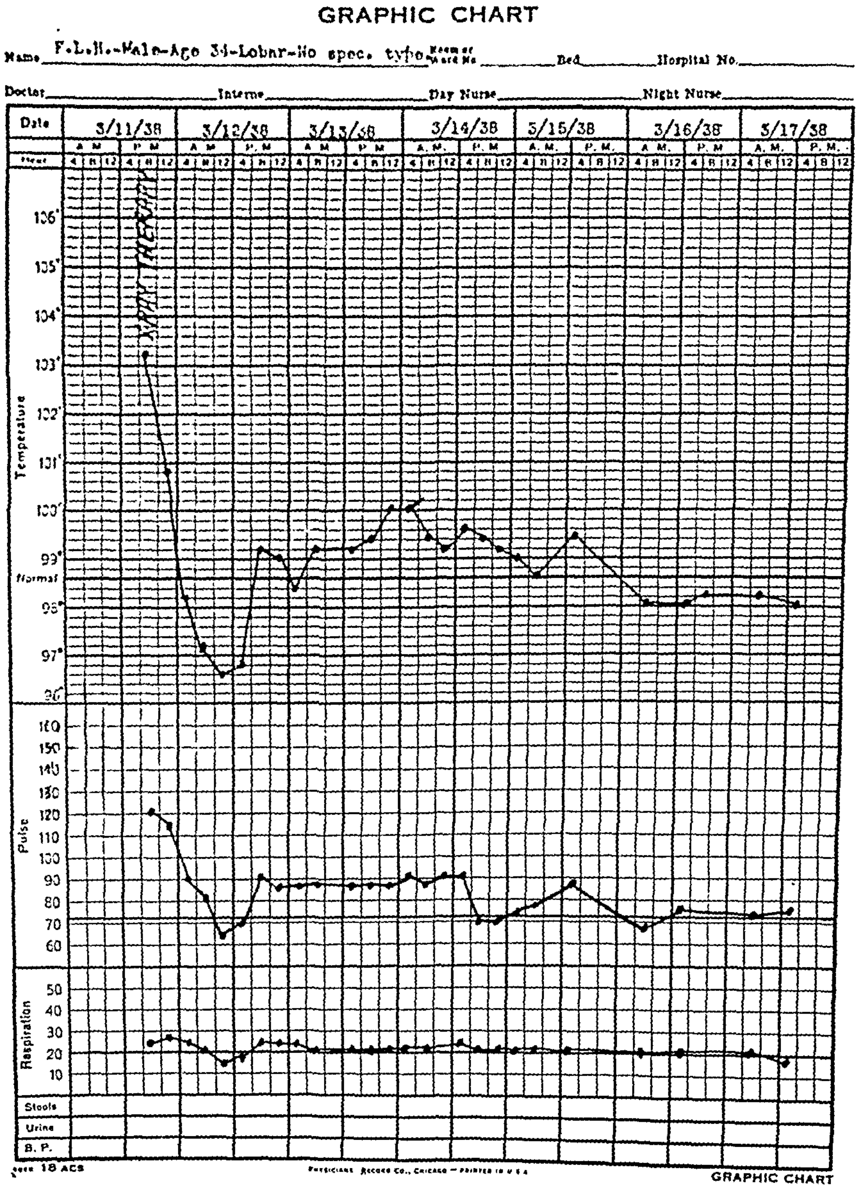

Chart 2. Case 2. Graphic chart of F. L. H. Note that temperature dropped six degrees within 24 hours after x-ray treatment was instituted; pulse and respiration rates corresponded to fall in temperature. (See Figures 2-*A* and 2-*B*, for radiographs of chest.)

In passing, it is interesting to note that in only 14 per cent of all the pneumonia cases admitted to the hospital was the attending physician satisfied to depend largely on his clinical findings, without radiographs, for evidence on which to base his diagnosis and treatment, and it is

sideration anything as regards the method of x-ray treatment (whether by bedside unit or not), seriousness of the disease, or any other variables. This figure is so close to the figure (20 per cent) secured the results secured by simple radiography alone. Study of Table VIII, wherein each of the 27 deaths in the series has been analyzed, seems to offer some explanation of the death rate. When we remember

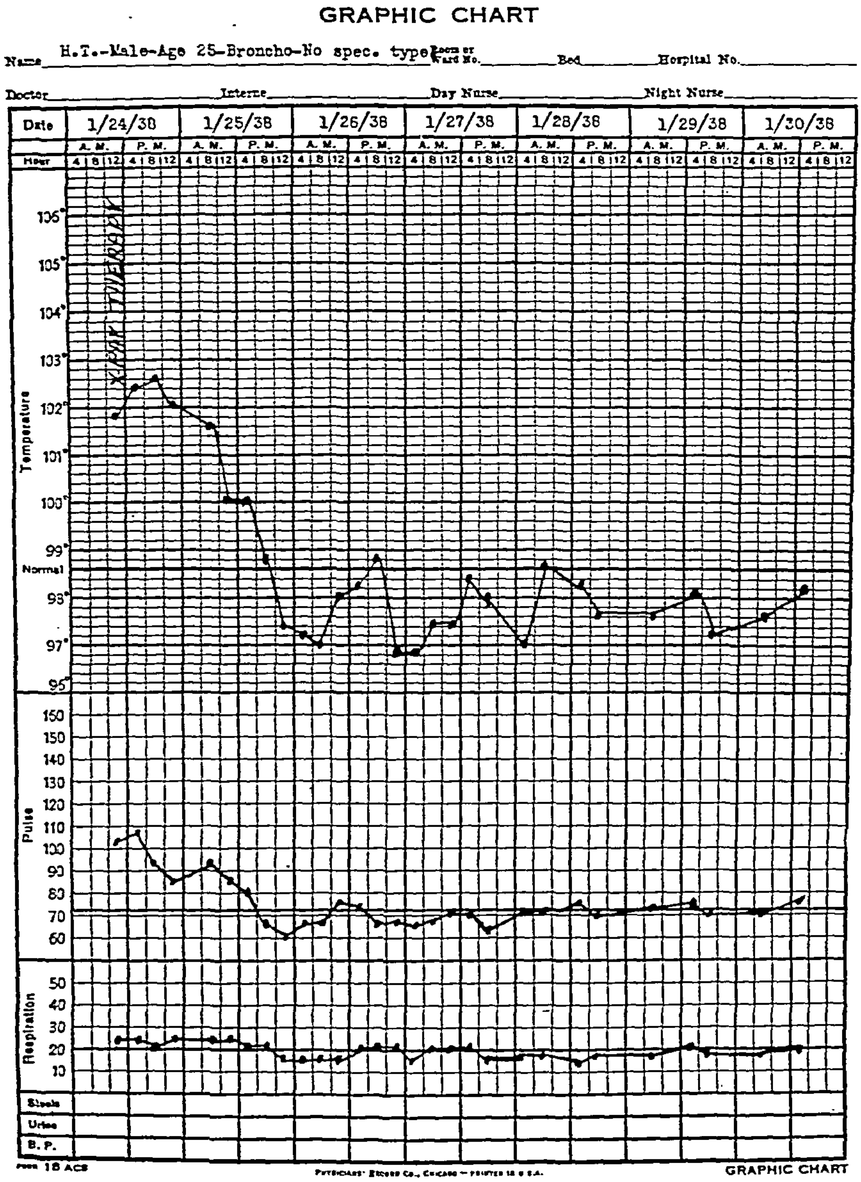

Chart 3. Case 3. Graphic chart of case H. T. (see Figure 3). Clinically considered as a bronchopneumonia on admission. Note five-degree temperature drop within 36 hours after institution of x-ray therapy. The patient was discharged in eight days. (See Figure 3 for radiograph of chest.)

for the untreated, but radiographed cases, that, on the surface, it would suggest that x-ray therapy in our series has proven of little value in reducing the mortality over the death rate for the 34 cases not even radiographed (see Table IV) to be 44.1 per cent, the death rate for our entire 138 cases is quite satisfactory.

Further analysis of Table VIII leads the writer to state definitely that only two out of the 27 fatal cases could have been classified as average pneumonias.

One of these was a lobar, Type 8, female, aged 64, who had both x-ray therapy and serum, but who did not appear to react favorably to either. She seemed to have no resistance and died within four days of entering the hospital, which was within six days of the onset of the disease. The other so-called "average" case was a lobar, Type 1, male, aged 50, suffering from a toxic myocarditis on admission, and who was "treated" with the bedside unit because he was too ill on the day after his

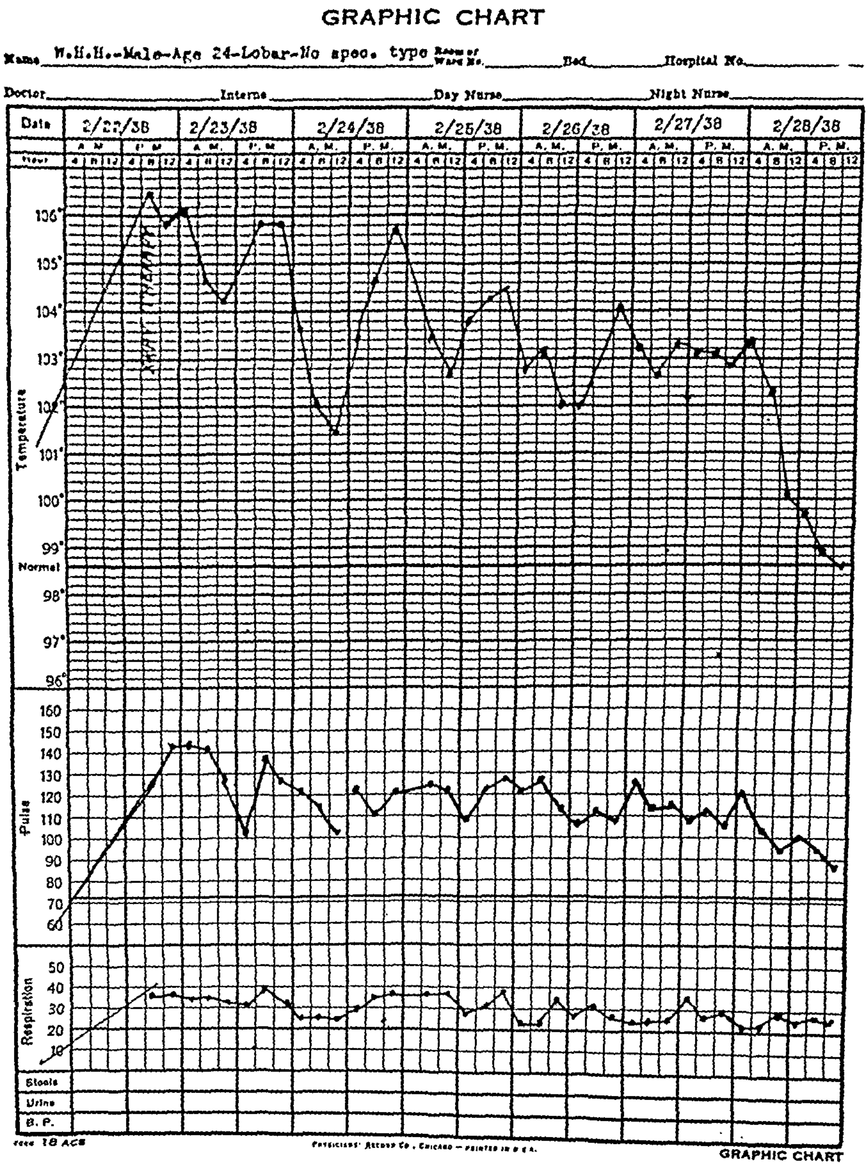

Chart 4. Case 4. Graphic chart of W. H. H. Note that temperature dropped five degrees within 36 hours of institution of the treatment. The temperature rose again, but the patient looked and felt much better than would be suggested by the chart, and further x-ray therapy did not seem necessary. He remained in the hospital 19 days. (Radiograph of the chest of this patient is shown in Figure 4.)

admission to be brought to the X-ray Department. In view of his condition when he was treated, he perhaps might better be classed as "bad" rather than "average." Our classification in this respect undoubtedly is weak, as we listed the cases according to the way they impressed us at the time of making the radiographs.

All of the other 25 fatal cases were either listed as bad or moribund, at the time of admission to the hospital. For this reason we shall not attempt to draw

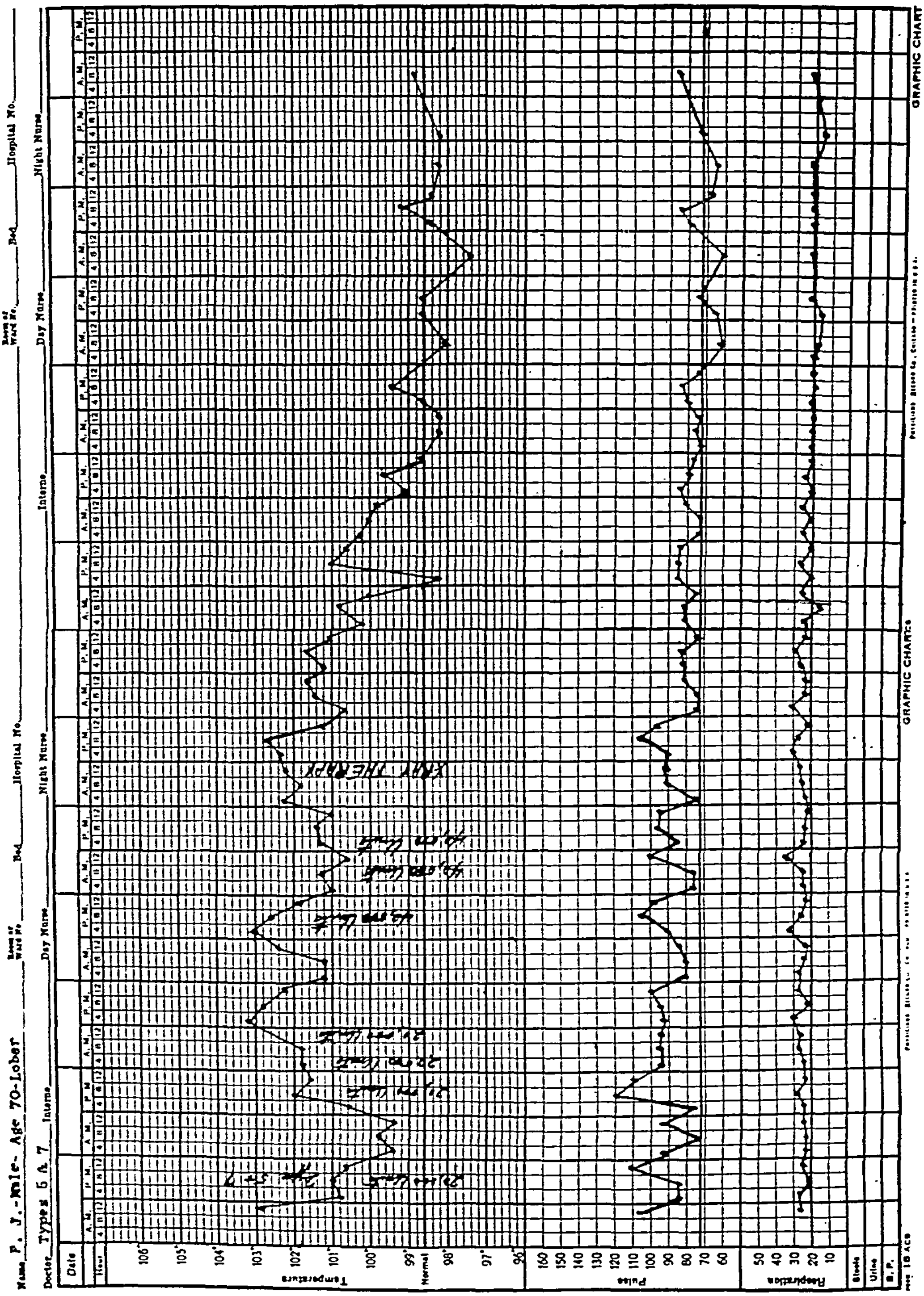

Chart 5. Case 5. Graphic chart of F. C. J. Note that patient recovered by lysis, beginning immediately after x-ray therapy. Two hundred thousand units of serum were given before x-ray therapy was instituted. A second sputum typing just before administration of x-ray therapy demonstrated a different type from that first found, and it was thought unwise to give more serum and x-ray therapy was tried. (See Figure 5 for radiograph of chest.)

any further comparisons between those who were given x-ray therapy, and those who were radiographed without having x-ray therapy, as this has already been covered in Table VII.

Of the 27 cases that died, 17 had had x-ray treatment. Although most of these 17 were treated immediately upon entrance to the hospital, and, therefore, they are listed as having been treated "early," nevertheless many of them were manifestly treated "too late" to offer much hope of aiding the recovery of the patient.

Treatment of a patient considered as moribund on admission to the hospital, even though the patient was treated as soon as he or she was admitted, could hardly be expected to turn the course of the disease. Incidentally, six of the 17 fatal cases were "treated" with the bedside unit because the attending physician felt that they were too ill to be moved to the X-ray Department. We have not felt that cases treated with the bedside unit should be chalked up as failure of the use of x-ray treatment, as the bedside unit is of low capacity and not designed for therapy.

As stated earlier in this presentation, the essayist felt that not only was the death rate of interest in pneumonia, but that the cost of the disease as represented by length of hospitalization, etc., deserved to be considered.

We have charted, therefore, in Tables IX and X, the average length of time the patients were found to have remained in the hospital, with and without x-ray therapy, and with various combinations of

TABLE VI.—CLASSIFICATION OF PNEUMONIAS ACCORDING TO AGE AND TREATMENT

(138 Cases)

1937–1938 Treatment		Under 10		10–20		20–30		30–40		40–50		50–60		60–70		Over 70	
		M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.
X-ray therapy	Rec.	12	12	8	2	3	2	5	1	1	4	1			2		
	Died	2	2							1				2	1	2	
No x-ray therapy	Rec.	15	7	5	1	5	3	2		1		1					
	Died	1		1	1					1	1		1	3			1
X-ray and other spec. medication	Rec.	7	3		3					1	1	1				1	1
	Died	1					1			1		1		1	2		
Total	Rec.	34	22	13	6	8	5	7	1	3	5	3			2	1	1
	Died	4	2	1	1		1			3	1	1	1	6	3	2	1
Moribund at time of giving x-ray (c) complications (p) portable therapy		2(c) 1(p)	2(c)				1(p)			1(p)				2 (1c)	1 (1c)	1 (1p)	

Showing in general, by age groups, the number of cases that recovered, and the number of cases that died, giving indication of the treatment given these cases. This Table includes only the 138 cases which passed through the X-ray Department for x-ray therapy and/or radiographs. The cases are herein considered under the general heading of pneumonia and not divided into broncho- and lobar variations.

TABLE VII.—CONSOLIDATION OF TABLE VI

	No. cases	Outcome	Males	Females	Death rate M.	Death rate F.	Average death rate
Chiefly x-ray therapy	63	Recovered	30	23	18.9%	11%	15.8%
		Died	7	3			
X-ray and other medication	25	Recovered	10	8	23%	33.3%	28%
		Died	3	4			
No x-ray therapy	50	Recovered	28	12	17.6%	25%	20%
		Died	6	4			

Demonstrates the death rates of the 138 cases. It is interesting to average the deaths of all those patients who had x-ray therapy, no matter what else was done, and secure the figure 19.3 *per cent which is very close* to the 20 per cent figure for those patients radiographed, but not given any x-ray therapy.

admission to be brought to the X-ray Department. In view of his condition when he was treated, he perhaps might better be classed as "bad" rather than "average." Our classification in this respect undoubtedly is weak, as we listed the cases according to the way they impressed us at the time of making the radiographs.

All of the other 25 fatal cases were either listed as bad or moribund, at the time of admission to the hospital. For this reason we shall not attempt to draw

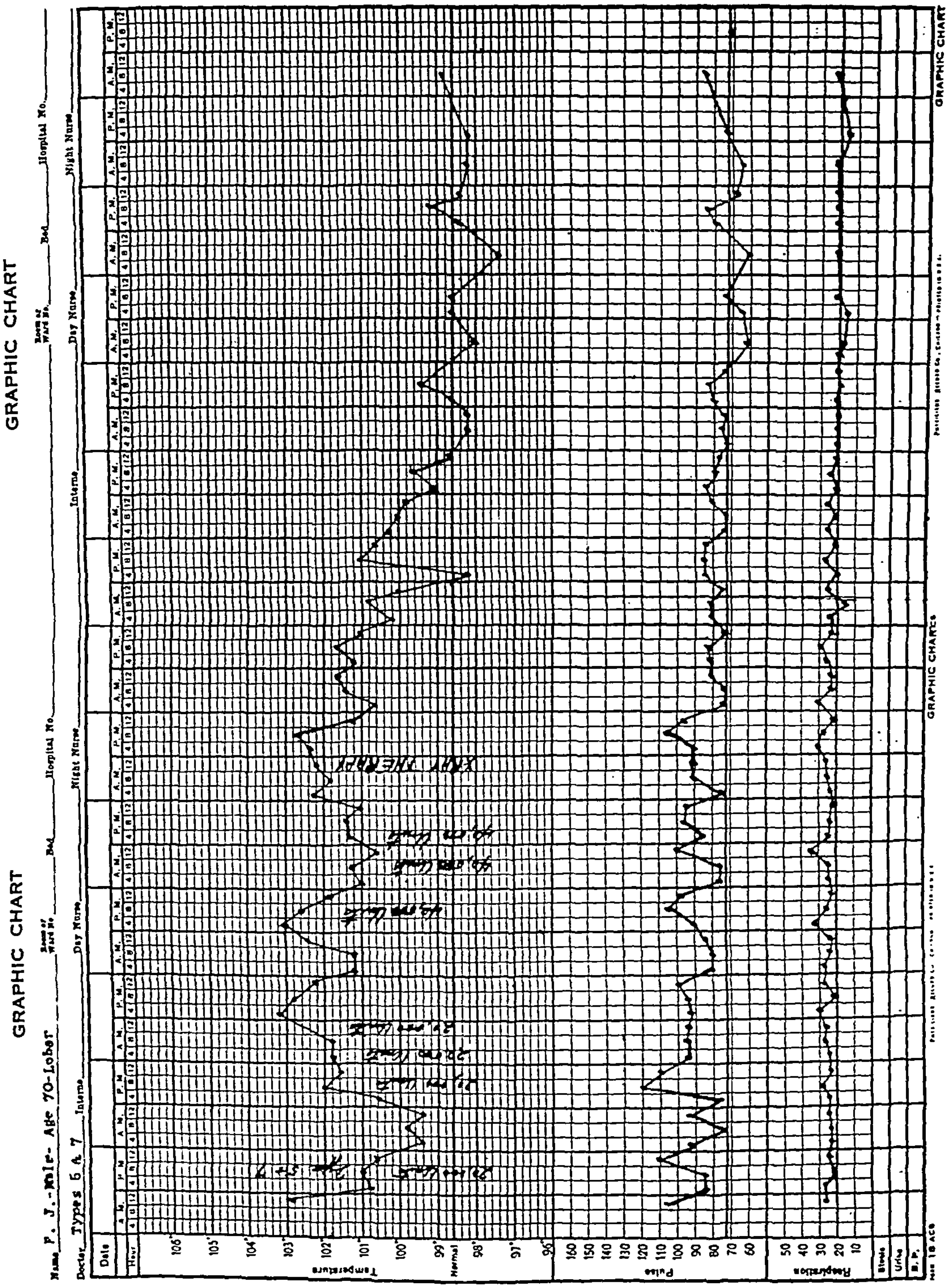

Chart 5. Case 5. Graphic chart of F. C. J. Note that patient recovered by lysis, beginning immediately *after* x-ray therapy. Two hundred thousand units of serum were given before x-ray therapy was instituted. A second sputum typing just before administration of x-ray therapy demonstrated a different type from that first found, and it was thought unwise to give more serum and x-ray therapy was tried. (See Figure 5 for radiograph of chest.)

TABLE VIII.—DEATHS

X-ray No.	Initials	Sex	Age	Broncho- or Lobar	Type	Condition on admission	Duration of disease before admittance	Total stay in hospital	Complications on admission	No. of Trts.	Trt. Early	Too Late	Portable	Serum—Yes	Serum—No	Sulph.—Yes	Sulph.—No	No. days O_2	Not given O_2	Complications during hospitalization. (Continued from admission or occurred during hospitalization: see previous column)
808-37	LB	M	15	Lob	No Sp.	Bad	6 da.	.5 da.		0					x		x	3		Otitis media—Pericarditis
736-37	AT	M	64	Lob	Not Typed	Bad	7 da.	.5 da.		1	x	x	x		x		x	5		Uremia
720-37	WH	M	3 mo.	Lob	Not Typed	Bad	?	10 da.		1		x			x		x	10		Atelectasis
721-37	DM	M	6	Lob	Not Typed	Bad	4 da.	10 da.	Appendix	1	x	x	x		x		x		x	Peritonitis
635-37	DC	M	42	Lob	No Sp.	Bad	7 da.	5 da.	Cardiac	1	x	x	x		x		x	5		Acute cardiac dilatation
613-37	JD	M	75	Bro	No Sp.	Bad	3 da.	5 da.	Cardiac	1	x	x			x		x	5		Cardiac hypertrophy
472-37	JB	F	44	Lob	Not Typed	Bad	?	11 da.	Abortion	0					x		x	4		Septicemia
432-37	LK	M	40	Lob	No Sp.	Mor	13 da.	2 da.	Nephritis	0					x		x	2		Toxemia
340-37	GW	M	63	Lob	No Sp.	Bad	7 da.	5 da.	Tuberculosis	0					x		x	3		Tuberculosis
321-37	PF	M	60	Bro	No Sp.	Bad	3 da.	5 da.	Cirr. Liver	0					x		x	5		Nephritis
154-37	JT	M	64	Bro	No Sp.	Mor	4 da.	2 da.	Heart	0					x		x	2		Dilated heart
85-37	CM	F	52	Bro	Not Typed	Bad	?	3 da.	Hernia & Hemiplegia	0					x		x	3		Old hemiplegia
72-37	LW	M	9 mo.	Bro	No Sp.	Bad	3 da.	96 da.		0					x		x	96		Empyema
70-37	LM	F	13	Lob	No Sp.	Bad	?	9 da.	Myocarditis	0					x		x	6		Toxic myocarditis
43-37	TB	F	70	Lob	No Sp.	Bad	3 da.	6 da.		0					x		x	4		
185-38	JD	F	64	Lob	8	Avg	2 da.	4 da.	Cardiac	1	x			x			x	4		Cardiac
149-38	CC	M	50	Lob	7	Bad	1 da.	4 da.	Myocarditis	1	x			x			x	4		Myocarditis
142-38	JP	M	63	Lob	Not Typed	Mor	2 da.	2 da.	Heart	1	2		x		x		x		x	Heart
120-38	JL	M	76	Bro	Not Typed	Bad	10 da.	5 da.	Myocarditis	1	x				x		x	4		Myocarditis—ascites
87-38	GW	M	48	Lob	1	Bad	5 da.	6 da.		2	x			x			x	8		Pleurisy—Abscess of Lung
54-38	DT	M	50	Lob	1	Avg	6 da.	3 da.	Myocarditis	1	x		x	x			x	3		Toxic myocarditis
221-38	JT	F	63	Lob	3	Bad	6 hr.	4 da.	Tuberculosis	1	x			x			x	4		Sup. of urine
395-38	RC	F	24	Lob	No Sp.	Bad	?	12 da.	Exoph. Goiter	1		x	x		x		x	6		Goiter—Surg.
375-38	GL	F	59	Lob	1	Mor	2 da.	3 da.		1	x				x		x	3		Hypertension—Nephritis
321-38	GP	M	64	Lob	5	Mor	9 da.	3 da.		1	x	x			x		x	3		Pleurisy
536-38	HM	F	1	Bro	Not Typed	Bad	5 da.	3 da.	Enl. Heart	1	x	x			x		x	3		Enlarged heart
472-38	BB	F	17 mo.	Bro	No Sp.	Mor	?	2 da.	Very Toxic	1	x				x		x	2		Severe toxemia

This is an analysis of the 27 fatal cases in the series of 138 given x-ray therapy and/or radiographed. Note that all but two were considered as "bad" or "moribund" at the time of admission to the hospital.

Note: "No Sp." type means that no specific type was found although types one through eight were searched for.

TABLE IX.—LOBAR PNEUMONIA

Total Number of Days Spent in Hospital

(Classification According to Age and Treatment)

Age	Under 10				10–20				20–30				30–40				40–50				50–60				60–70				Over 70			
	Rec.		Died		Rec.		Died		Rec.		Died		Rec.		Died		Rec.		Died		Rec.		Died		Rec.		Died		Rec.		Died	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
Chiefly x-ray plus O_2	43	65	10		31					14		12	22					9	5					3		36	8					
No. cases	4	4	1		3					1		1	2					1	1					1		1	1					
av. days	11	16	10		10					14		12	11					9	5					3		36	8					
No O_2 (had x-ray)	35		10		22	9			19				31	41			18	38			30						2					
No. cases no O_2	3		1		3	1			1				3	1			1	2			1						1					
av. days	12		10		7	9			19				10	41			18	19			30						2					
X-ray plus serum and sulph. and O_2		30																			18					69						
No. cases		1																			1					1						
av. days		30																			18					69						
No O_2																																
No. cases no O_2																																
av. days																																
X-ray and serum plus O_2	39																18	21	6				4					8	27			
No. cases	4																1	1	1				1					2	1			
av. days	10																18	21	6				4					4	27			
No O_2 (had x-ray and serum)	24					13																										
No. cases no O_2	2					1																										
av. days	12					13																										
X-ray and sulph. plus O_2																																
No. cases																																
av. days																																
No O_2 (had x-ray and sulph.)						13																										
No. cases no O_2						1																										
av. days						13																										
Serum and sulph. and O_2													14																			
No. cases													1																			
av. days													14																			
No O_2 (had serum and sulph.)																																
No. cases no O_2																																
av. days																																
Serum and oxygen no x-ray	31																															
No. cases	1																															
av. days	31																															
No O_2 (had serum)									18																							
No. cases no O_2									1																							
av. days									18																							
Sulph. plus O_2	52				8																											
No. cases	1				1																											
av. days	52				8																											
No O_2 (had sulph.)	18								14				12																			
No. cases no O_2	1								1				1																			
av. days	18								14				12																			
No spec. trt. but oxygen	68							5	12	12									2	11							5					6
No. cases	3							1	1	1									1	1							1					1
av. days	22							5	12	12									2	11							5					6
No. spec. trt.—no oxygen	18				31				17								8				77											
No. cases no O_2	1				1				1								1				1											
av. days	18				31				17								8				77											

Number of days spent in the hospital and the length of stay with various combinations of treatments used, and recoveries and deaths according to age groups in the cases of lobar pneumonia. Also, when oxygen was or was not used with other medications. (Explanatory example—First column: Four males, under 10 years of age were treated with oxygen, but the main dependence, aside from oxygen, was placed on x-ray therapy. These four cases remained in the hospital a total of 43 days, or an average of 11 days per case.)

TABLE X.—BRONCHOPNEUMONIA

Number of Days Spent in Hospital

(Classification According to Age and Treatment)

Age	Under 10				10–20				20–30				30–40				40–50				50–60				60–70				Over 70			
	Rec.		Died		Rec.		Died		Rec.		Died		Rec.		Died		Rec.		Died		Rec.		Died		Rec.		Died		Rec.		Died	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
Chiefly x-ray plus O_2	49	51		50					6	14																8					10	
No. cases	4	5		2					1	1																1					2	
av. days	12	10		25					6	14																8					5	
No O_2 (had x-ray)		21			11	9			8									24														
No. cases no O_2		3			1	1			1									1														
av. days		7			11	9			8									24														
X-ray and sulphanilamide plus O_2	18																															
No. cases	2																															
av. days	9																															
No O_2 (had x-ray and sulph.)		30			18	10																										
No. cases no O_2		1			1	1																										
av. days		30			18	10																										
Serum and x-ray plus O_2																							3									
No. cases																							1									
av. days																							3									
No O_2																																
No. cases no O_2																																
av. days																																
No specific treatment (general care), no O_2	82	87			18				34	18																						
No. cases	4	5			1				1	1																						
av. days	20	17			18				34	18																						
No specific treatment with O_2	116	29	96			26	9			23													3	7								
No. cases O_2	4	2	1			1	1			1													1	2								
av. days	29	14	96			26	9			23													3	3								

The bronchopneumonias. Similar to Table IX which covered the lobar pneumonias (see footnote, Table IX)

dioxide addition. The Alison report is of interest and there would seem to be no contra-indication for the use of this type of treatment in addition to x-ray therapy, if so desired by the attending physician.

Only 15 patients in our series were given sulphanilamide; one of these died. This group is too small to draw any conclusions, and, therefore, it is reported only as a matter of interest.

In our series, 21 patients received serum. In at least one case, after giving 200,000 units without satisfactory clinical results, another sputum examination showed a different type than at first, and it was not felt advisable to resort to more serum. X-ray therapy, at this stage of the disease, was followed by response within 12 hours, and the patient then recovered by lysis and was discharged six days later. It might appear that x-ray therapy should not be credited with the recovery of this patient, since cases which are given serum may recover by lysis (3), but the clinical improvement did follow almost immediately after the x-ray therapy and, therefore, the x-ray therapy deserves at least some consideration.

The possibility of serum reactions, of course, does not preclude giving serum to sensitive patients, unless these symptoms are of an unusually severe character (3). However, we must beware of allergic patients, or those who give a history of asthma, hay fever, eczema, etc. Also, we may expect serum reactions if tetanus serum has been given within six months. If no serum of any kind has been given

within two years, however, and the history is clear, there probably will be little or no reaction. As every physician knows, serum reactions may occur at any time following the administration of the serum—from an immediate reaction up to ten days or later—and be of all stages of severity from sudden death to an urticaria. With the use of x-ray therapy, in the moderate amounts which seem to affect acute pneumonias, we do not have to consider reactions. Although very enthusiastic over our results with this mode of treatment, we hardly yet feel justified in withholding serum when the sputum typing indicates that a specific serum is available. Table XIV lists the serum reactions (of any degree) that occurred in our series (42.8 per cent).

Powell (1) stated, "Complications still occur with about the expected frequency." (In our series there were eight patients who received x-ray who had complications—out of 87 treated—or approximately 9 per cent.) This compares with 12 patients out of 41 (29 per cent) who did not have x-ray therapy but who did have complications. This would seem to be too large an improvement in favor of the x-ray treated cases to be lightly overlooked.

Careful review of the cases with the attending physicians, leads us to feel that in the series reported the satisfactory outcome was due to x-ray therapy in not less than 54 cases (probably many more), but, in arriving at that figure, all cases in which there seemed to be any possible room for argument were eliminated.

TABLE XI.—SUMMARY OF TABLES IX AND X

Number of Days Spent in Hospital

			M.			F.		
			Chiefly X-ray	X-ray and Other	No X-ray	Chiefly X-ray	X-ray and Other	No X-ray
Broncho-	Recovered	No. patients	7	3	12	12	1	10
		No. days	74	36	300	127	20	182
		Av. no. days	10	12	25	10	20	18
	Died	No. patients	2	1	2	2	..	1
		No. days	10	3	72	50	..	3
		Av. no. days	5	3	36	25	..	3
Lobar	Recovered	No. patients	21	9	17	12	6	1
		No. days	251	126	398	228	175	12
		Av. no. days	12	14	23	19	29	12
	Died	No. patients	6	3	3	2	2	3
		No. days	43	16	11	15	8	22
		Av. no. days	7	5	3	7	4	7

Patients treated chiefly by x-ray remained in the hospital about half as long as those who had no x-ray therapy.

TABLE XII.—CLASSIFICATION OF PNEUMONIAS ACCORDING TO TYPE

Treatment	Type I		Type II		Type III		Type IV		Type V		Type VII		Type VIII		Non-spec.	
	Rec.	Died	Rec.	Died	Rec.	Died	Rec.	Died	Rec.	Died	Rec.	Died	Rec.	Died	Rec.	Died
X-ray only	1	1	1				1			1			2		23	4
X-ray and other	9	2			2	1	2					1		1	6	
Serum only, no x-ray	2															

Note: "Non-spec." means that no specific type was found although types one through eight were searched for.

SUMMARY AND CONCLUSIONS

1. A series of 138 cases of pneumonia have been reviewed (of which 88 had some form of x-ray therapy) in an attempt to demonstrate the value of x-ray therapy in the treatment of acute pneumonia.

TABLE XIII.—USE OF OXYGEN

Totals	Chiefly with X-ray		Without X-ray		With X-ray and Other Treatment	
	No. Patients	Days	No. Patients	Days	No. Patients	Days
Lobar	21	95	11	39	14	94
Broncho-	11	49	10	155	7	36
Total	32	144	21	194	21	130
Average	$4^1/_2$ days		$9^1/_4$ days		$6^1/_3$ days	

2. In x-ray therapy we have a simple and easy method of treatment which appears to influence favorably the course of many cases of acute pneumonia. Equipment for giving this type of treatment is now available in most hospitals; but it should be supervised by a qualified roentgenologist and given with properly calibrated equipment.

3. The length of hospitalization is decreased by x-ray therapy.

4. The temperature returns to normal more quickly.

5. The frequency of complications seem definitely lessened.

6. The death rate, as compared to that from other methods of treatment, has been lower, as long as the patients were even radiographed, but as compared to cases not even radiographed the percentage in favor of some form of x-ray seems almost incredible.

7. Contra-indications appear to be *nil*, whereas other types of medication, especially serum, may be definitely contra-indicated.

8. Any other treatment desired by the attending physician may be given in conjunction with x-ray therapy.

9. No reactions to x-ray treatment have been noted in this series, while serum reactions may be of varying degrees.

10. Many cases of pneumonia are hospitalized too late to expect good results from any type of therapy. Education of the public and of the medical profession is the only way to overcome this tendency to delay hospitalization. Practically all the cases that died (in this series) had a bad prognosis from the time of admission to the hospital.

TABLE XIV.—X-RAY REACTIONS *vs.* SERUM

Total No. Cases Reviewed	138
Total no. cases receiving x-ray (either alone or combined)	87
Total no. x-ray reactions	0
Total no. patients receiving serum	21
Total no. serum reactions	9
Percentage of serum reactions of varying degree—sufficient to be reported in daily notes of nurses or physicians	42.8%

11. Further reports from others working on this problem are necessary in order to estimate accurately the value of x-ray therapy in the treatment of pneumonia, as this series is somewhat small and the treatments by x-ray were too often complicated by other medication.

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LIPIODOL GRANULOMA IN FALLOPIAN TUBES LOCALIZED BY INTRA-UTERINE DIODRAST INJECTION, WITH SPECIAL REFERENCE TO THE VALUE OF FOLLOW-UP X-RAY FILMS[1]

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LIPIODOL has been used in conjunction with the x-rays as a diagnostic test of tubal patency since the report of C. Heuser (1), in 1924. Its radiopacity was first appreciated by Sicard and Forestier (2), who recommended this iodine oil compound for general diagnostic adoption, in 1922. The literature contains numerous reports in which excellent radiographic films are reproduced showing shadows of lipiodol within the tube lumen as well as the "spill" into the peritoneal cavity.

However, in gynecology, especially in the investigation of sterility, a number of reports of the last ten years has brought to light certain undesirable sequelæ which are generally overlooked and perhaps under-emphasized.

The purpose of the present communication is to call attention to one of these sequelæ, namely, the persistent retention of lipiodol within the fallopian tubes and to the need of taking follow-up films in such cases.

In a previous paper (3) I have reported a follow-up of 43 patients who gave a history of having had an intra-uterine injection of lipiodol. In 22 of these, a skiagram of the pelvis was subsequently available. Fifteen of the 22 showed some lipiodol residue. In the same paper reference was made to Rabbiner's (4) report of contrast media in the pelvis demonstrated by an x-ray plate which was taken in four cases several weeks and months after lipiodol injection. Since then an opportunity has presented itself of studying the films in five additional instances. They were taken from an unselected group of 31 cases, in 26 of which for various reasons a film was not obtained. Lipiodol residue was present in three of the five cases for from one month to a year after the injection. Whether and to what extent deposits of lipiodol may have been encountered in the 26 cases not controlled later by an x-ray plate, is purely conjectural. Opacities found after intervals of more than a year may be so reduced in size as to be confused with phleboliths or small ureteral calculi. In a recent case lipiodol residue was found scattered in the pelvis four years after the injection.

Although the presence of post-injection opacities may not be of further significance than perhaps to suggest the presence of peritoneal cysts or adhesions surrounding the oil globules, the presence of foreign body granuloma within the tube lumen which results from persistent irritation of the retained oil is of greater clinical importance. This applies particularly in a patient who has been investigated by lipiodol for sterility and whose tubes were only partially obstructed. I have reported three such instances of tubal blockade due to lipiodol residue, in the communication mentioned above, and subsequently, met with several additional cases. These corroborate the earlier report by E. Ries (5), which dealt with foreign body reaction induced by lipiodol in the tubes. Similar reports were published by J. Novak (6), G. Albano (7), R. S. Hoffmann (8, 9), W. Odenthal (10), R. Zimmerman and H. Nahmmacher (11), R. Schröder and H. Jacobi (12), and G. K. F. Schultze (13).

In order to identify the lipiodol residue in the tubes, it is obviously necessary to introduce another x-ray opaque substance

[1] This is one of a series of papers contributed by friends and former pupils of I. Seth Hirsch, M.D.

into the uterus. However, a second injection of lipiodol is not advisable nor has this been generally adopted by ardent advocates of iodized oil. For this reason I have felt that when a radiopaque fluid is to be reinjected it is best to utilize one of the crystalloid organic iodides commonly used in intravenous urography such as hippuran, skiodan, or diodrast (Neustaedter, 14, Titus, 15, Morse and Rubin, 16). These afford excellent radiopaque shadows and owing to their rapid resorption leave no residue within the uterus, tubes, or peritoneal cavity. As the fluid passes through the tube, it is apt to be totally or partially blocked by the organized lipiodol residue. The procedure is analogous to the method employed to locate the presence of stone in the ureter by injecting such media intravenously or through the ureteral catheter.

A case recently under my observation illustrates the application of intra-uterine diodrast injection for locating the obstructed portion of the fallopian tube and of identifying the lipiodol residue in it.

Fig. 1.

Fig. 2.

Fig. 1. M. McG. Lipiodol residue four months after intra-uterine injection. Several opacities appearing on the film were not identified as lipiodol residue, resembling possible phleboliths or ureteral calculi.

Fig. 2. M. McG. Diodrast injection showing the left isthmus down to but not past the irregular shadow seen in Figure 1. This shadow disappeared with the removal of the ampullary portion of the left tube which, on microscopic section, showed foreign-body giant cells resembling tubercles.

Mrs. M. McG., 29 years old, married four years, had been trying to become pregnant for the past two years. She stated that she had had a tubal insufflation which demonstrated non-patency. On June 27, 1938, a second tubal insufflation also demonstrated non-patency. She was admitted to the gynecological service of Mount Sinai Hospital on Oct. 24, 1938, for further study and operation. Preliminary to injection of diodrast into the uterus, a "flat plate" was taken which showed an irregular shadow, caterpillar-like, in the region of the lower left portion of the sacrum (Fig. 1). This proved to be the residue from a lipiodol injection which the patient recalled having had four months previously. Diodrast was then introduced into the uterus. The x-ray film showed no shadow corresponding to the right tube.

On the left side the opaque fluid was seen reaching down to the shadow found on the flat plate (Fig. 2).

At operation, Nov. 3, 1938, the uterus was found in retroflexion, bound down to the posterior cul-de-sac by numerous fine and filmy band-like and string-like adhesions. Both tubes were markedly thickened and bound down with the ovaries deeply in the cul-de-sac by numerous filmy adhesions. The right tube was the seat of nodular thickenings which were marked at its inner half. On the left side at the cornual angle just beneath the tube, a yellowish caseous mass the size of a pigeon's egg was located. In order to determine the part of the tubes which remained patent, a uterine cannula connected to an insufflation apparatus was introduced into the uterine cavity. The lumen of the right tube was thus found to be completely obliterated; hence it was removed. The left tube was found to be thickened and nodular and was removed segment by segment from the fimbriated end toward its uterine insertion, till a point 1.5 inches from the latter was reached, when CO_2 gas was seen to percolate through the lumen.

A flat plate taken after the operation showed that the residual shadow originally seen was no longer present. The portion of the left tube which contained the lipiodol residue showed, on section, caseating salpingitis *resembling* tuberculous salpingitis but no tubercle bacilli were found. Incidentally, the mass of caseous degeneration was found to consist of a cystic structure with complete fibrosis of the cyst wall, the inner surface showing caseation with calcium deposits; no ovarian tissue was recognizable.

It is noteworthy that the diodrast was completely absorbed after one-half hour. Eighteen days following the laparotomy, an insufflation demonstrated the left isthmic portion to be patent but stenosed. Diodrast passed readily through this stenosed tube end and was rapidly resorbed. There was no sign of peritoneal irritation either as a result of the repeated insufflations or of the diodrast injections.

SUMMARY AND CONCLUSIONS

Lipiodol injection into the uterus is frequently followed by retention of the iodized oil in the tubes as well as in the pelvic and upper abdominal cavity (17). Eighteen out of 27 cases in which a follow-up film was available showed opaque deposits at periods of from one month to one year and longer.

Retention is common when the tubes are sealed or partially patent. The damage is more serious in the latter cases in which the partially permeable lumen becomes obliterated by organization and foreign body granuloma. The value of follow-up films is emphasized. If a radiopaque substance is to be used, the crystalloid iodides have the advantage of being injected more than once and are especially useful for purposes of identifying lipiodol residue within the tube lumen.

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tological findings, would strongly suggest Hodgkin's disease.

Comment on Radiation Therapy.—The areas primarily involved or those that eventually recurred were treated with high voltage irradiation consisting of, in some cases, 180 kv., 4 ma., 0.5 mm. copper and 1.0 mm. aluminum filters, 50 cm. distance. In a few cases, 190 kv., 4 ma., 0.5 mm. copper and 1.0 mm. aluminum filters, 50 cm. distance were employed. Between 175 and 200 r were administered per treatment and per area. The results did not vary appreciably, no matter what kilovoltage was employed. As a rule, treatment was discontinued when the nodes in the area irradiated revealed complete regression, so that at no time was the full quota of skin tolerance approached.

Prophylactic irradiation, recommended by some therapists, was not employed. Ratkóczy (4) stresses the uselessness of irradiation during the periods of regression. Furthermore, in view of the presence of anemia in patients with lymphogranulomatosis intensive and persistent irradiation is obviously contra-indicated. Panteleroentgenotherapy as a means of combating Hodgkin's disease is rejected by Gilbert (5), who prefers local therapy.

Craver (2) discusses the question of choice between 140 kv. x-rays and 200 kv. x-rays as arbitrary with the therapist. He attests, however, that while regression of superficial nodes can be brought about by low kilovoltage, a 200 kv. technic is preferred for deep-seated lesions in Hodgkin's disease so as to spare the skin.

Desjardins (6) dislikes high kilovoltage (200 kv.) because, first, it may affect the patient adversely if repeated many times, and, second, it leaves no recourse to further therapy if lesions recur.

In the series presented herein, no contra-indication to the use of high voltage therapy was observed in view of the paucity of the symptoms which necessitated only suberythema doses for the local recurrences or exacerbations.

It is to be regretted, however, that when the terminal stage of the disease was reached the nodes appeared to have become radioresistant. In some instances one is reminded of a forest fire where, as soon as one area is extinguished, another site of conflagration is discovered, each one in turn becoming more resistant to quenching.

SUMMARY AND CONCLUSIONS

Eight cases of Hodgkin's disease are reported, five of which were observed until their demise.

Two of the patients lived nine and sixteen years, respectively, from the beginning of the primary lesion.

One unusual case with a meningeal complication is reported in detail.

Irradiation served to delay the ultimate result. Involvement of the abdominal nodes was, as a rule, a terminal manifestation and hastened exodus.

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THE INDIRECT RADIOGRAPH[1]

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From the X-ray Laboratories of the N. V. Philips' Gloeilampenfabrieken

DURING the last few years increasing interest has been shown in the indirect radiograph in which the film is not obtained by direct contact with the intensifying screen, but from an image on a fluorescent screen by means of a lens or system of lenses. Up to the present, the aim in the application of this indirect method has been merely to replace radioscopic examination by a method which was less dangerous, and, in addition, to offer certain other advantages, such as better documentation. In this connection we refer, for example, to the publications by Janker (1) and de Abreu (2).

Naturally, such means as were available have been employed in the practical application and the method has been adapted as well as possible to these means. At this stage it may perhaps be useful to try to find the conditions under which this method—which in the future will undoubtedly be found to be of great significance—gives the best result. The outcome of a number of tests and calculations for the purpose of finding these optimum conditions form the subject of this paper. Here we have thought not only of replacing the radioscopic image by the small film, but have also investigated the extent to which the reduced radiograph is inferior in quality to the radiograph by the usual method.

1. *The Optimum Radiograph: The Law of Uniformity.*—The indirect method is distinguished from the direct one through its exposure by means of a lens, which naturally entails a loss of light. Though it is true that because the reduction is the size of the image the amount of light per unit of surface area in the image is increased again, we shall see later that in the reproduction a considerable loss in light intensity occurs and that even with the fastest lenses the light intensity in the image is still only about one-tenth of that obtained with direct contact between screen and film. This loss of light intensity is mainly responsible for the loss in quality in the reduced radiograph. Now we know that for the normal radiograph of a moving object the recording conditions are best when the three causes of unsharpness—geometrical unsharpness (U_g), unsharpness due to movement (U_m), and unsharpness attributable to the screen (U_s)—are equal (3, 4):

$$U_m = U_s = U_g \qquad (1)$$

Here mean values are to be taken for the values U_g and U_m which are not constant for the whole image. We have called this condition the law of uniformity (3). Actually, it is based on the fact that the product of $U_m \times U_s \times U_g$ is a measure of the amount of light reaching the film and that, therefore, at a given value of the product, a given density is achieved. Now the sum of three figures with constant product is smallest when the figures are equal, as can easily be checked by figures taken as examples. This demonstrates the law of uniformity.

Strictly speaking, Condition (1) applies only when an x-ray tube with rotating anode is used (which is certainly preferable for this special purpose) and when the focal screen distance remains constant. By varying this distance, for instance to one-half, a four times greater intensity of radiation is obtained at a twice greater geometrical unsharpness, U_g. The product, $U_m \times U_s \times U_g$, therefore, becomes only twice greater at this reduced distance and the intensity quadruples. This is a reason for making the distance as small as possible when using a rotating anode: in fact, as small as other considerations, such

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as distortion and enlargement of image, permit.

Further, in the deduction of the law of uniformity no mention has been made of tube voltage or contrast, but the conclusion is independent of all these circumstances; it applies generally under the said conditions.

in order to obtain a greater sensitivity, so that U_s is increased. Finally, the unsharpness in the small image is about 2.7 times greater than in the direct image.

The loss in sharpness of the image is determined by the ratio of the amount of light per square centimeter in the reduced image, I', to the amount of light, I, that

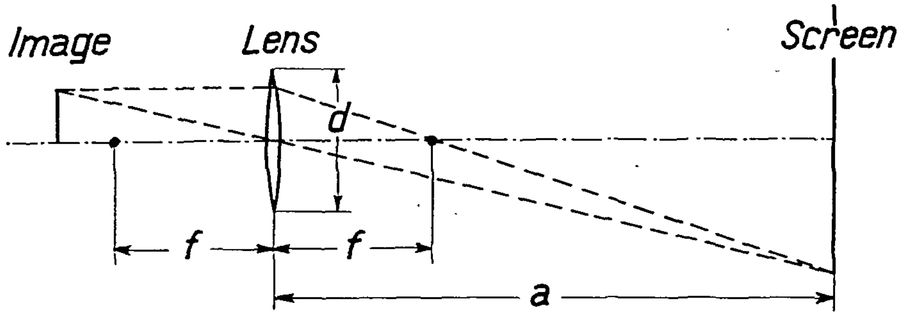

Fig. 1.

Also, in the case of indirect reproduction there is no change in the law of uniformity. We will take as a basis a radiograph made according to the ordinary method, which we will assume to be optimum, and substitute for the double intensifying screen a single screen which is recorded on film by means of a lens. If we keep to the same x-ray tube and also the same screen, we shall, for instance, have to expose twenty times longer to give the film sufficient density. As a consequence, the unsharpness due to movement will be greatly increased, to say nothing of the large dose of rays to which the patient is exposed, and the fact that the tube will probably not be able to withstand the much increased load. We must, therefore, select another procedure and the law of uniformity shows the way. We must arrange once again that approximately $U_m = U_s = U_g$, but in this case the product must be twenty times greater. We must multiply each of the factors U_m, U_s, and U_g by $\sqrt[3]{20}$ = about 2.7; and, therefore, we select a tube with a wider focus to increase U_g, increase the exposure duration 2.7 times to increase U_m, and use a screen with a coarser grain and a thicker layer than our intensifying screen would be present per square centimeter of film in the case of a direct image. The factor k, which indicates the increase in the unsharpness of image, is determined by

$$k = \sqrt[3]{\frac{I}{I'}}. \qquad (2)$$

There are, it is true, some other factors which can influence the density of the reduced image, but these are much smaller than the above-mentioned ones and, moreover, partly compensate each other. The influence of these factors is all the more negligible since only the cube root counts. For instance, one of these factors is that the density in the reduced image, in connection with projection, must preferably be much less than that to which we are accustomed in the direct image. We also have assumed that the film sensitivity is the same in both instances: this need not be the case, for fundamentally the grain may be larger in the direct image than in the case of the reduced image, as we shall see later. On the other hand, however, the color of the light with the usual intensifying screens is not as suitable for modern films as that emitted by coarse-grained screens, to which we have to give

preference for indirect radiographs. Experience has taught us that in both cases practically the same sensitivity may be reckoned with when, for the indirect exposures, Kodak Super XX panchromatic, Agfa Isopan ISS 22/10° or Agfa Isochrom 17/10° DIN is used.

The difference in gradation also plays a part, as this influences the permissible voltage on the x-ray tube: a higher voltage is permissible with films having a steep gradation (5).

It is advantageous to select a somewhat higher voltage than would be favorable with direct exposures, as here increased sharpness is obtained with a certain loss of contrast: through the higher voltage, the x-ray output is increased and, consequently, the produce $U_m \times U_s \times U_g$ becomes smaller for a given density. This means, in spite of a much greater unsharpness of the indirect image as compared with the direct image, an increase in perceptibility. Due to such a compromise, the factor I/I' is decreased. We also gain light intensity in the reduced image by reduction of the focus–screen distance, as explained under Section 1. A compromise which gives about the optimum result, is obtained if with the indirect exposure the focus–screen distance is reduced to one-half; and if, at the same time, the voltage is increased about 30 per cent. The sharpness of the obtainable result is then about doubled.

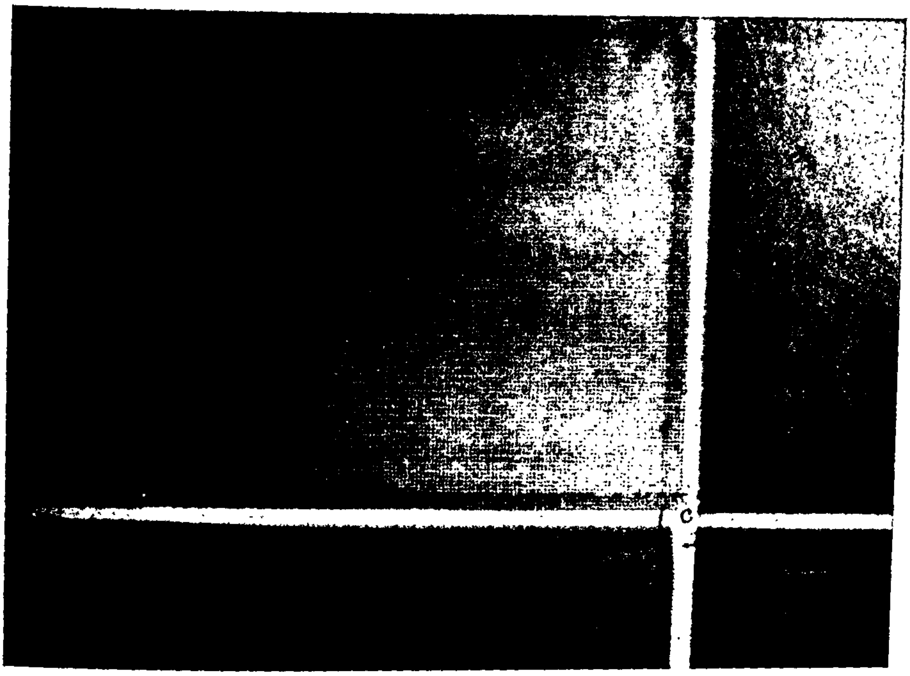

Fig. 2.

2. *Illumination Loss with Indirect Recording.*—We can easily calculate the ratio I'/I. Assume the diameter of the lens to be d, and the focal distance to be f (Fig. 1). The aperture, d, is in the case of the fastest commercial lenses $f/1.5$. Let the screen–lens distance be a. The relation of the light passing through the lens to the total amount of light emitted by the screen is

$$\frac{\pi d^2}{4} : 2\pi a^2 = \frac{d^2}{8a^2}.$$

If the reduction is n-times, then the surface area over which the light passing through the lens is distributed becomes $1/n^2$ times that of the screen and consequently the light intensity in the reduced image becomes $n^2d^2/8a^2$ times that in a

film immediately in contact with the screen and $n^2d^2/16a^2$ times that in a film between two screens. Now n is approximately

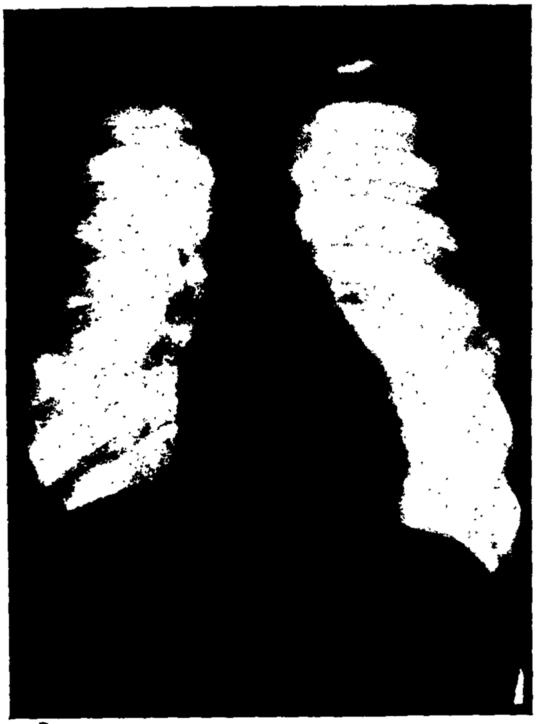

Fig. 3.

a/f, so that the last result may also be written in the form

$$\frac{I}{I'} = 16\left(\frac{f}{d}\right)^2 \qquad (3)$$

Applying (2), we find for the increase in unsharpness the factor:

$$k = \sqrt[3]{16\left(\frac{f}{d}\right)^2} \qquad (4)$$

If we halve the distance and increase the voltage 30 per cent with the indirect exposure, to approach optimum conditions as discussed above, this becomes:

$$k' = \sqrt[3]{4\left(\frac{f}{d}\right)^2} \qquad (4\text{-}a)$$

Now the value of f/d is generally not smaller than 1.5 in the case of camera lenses. Special lenses with larger aperture exist, however: the R-Biotar (6) of Zeiss has an aperture $f/0.85$, with f = 4.5 or 5.5 cm. Its unsharpness is, however, larger than with the commercial lenses mentioned below and certainly too large for images greater than 16 × 16 mm.[2] near the focal plane. With a lens of this aperture ratio the reduced image would, according to Formula (4), have an unsharpness $\sqrt[3]{11.5} = 2.2$ times as great as would be possible with the ordinary method. Therefore, under the given circumstances a tube with a rotating anode would give about the same degree of sharpness in a reduced image as a tube with stationary anode by the ordinary method, since the comparative unsharpness for these two types of tube is about this amount. This rule also applies when using commercial lenses with an aperture of $f/1.5$ when the distance is halved at the same time and the voltage increased about 30 per cent, in which case Formula (4-a) may be applied.

3. *Unsharpness of Film and Lens.*—There is an additional unsharpness in reproduction, owing to the fact that the lens does not reproduce a point as a point but as a circle (circle of confusion) and that the film does not have an infinitely small grain. Strictly speaking, it would be necessary to examine in what way these last two magnitudes vary with the speed of the lens and with the sensitivity of the film in order to arrive at a more complicated law of uniformity for the reduced image. However, these relations are not so simple. For the present the best thing is to require that the unsharpness produced by imperfect lens correction and grain of the film shall be small compared with the unsharpness that would be produced by ideal reproduction d[illegible] causes already mentioned.

As regards grain, we have [illegible] the rapid development of [illegible] during the last few years [illegible] mands of miniature phc[illegible] firms now carry fine-gr[illegible] suitable methods of devel[illegible] enough to obtain a fin[illegible] will satisfy the above [illegible] measuring the size of [illegible]

films, we found values varying between a few micra and about 25μ. When suitable material is used, the size of grain need not exceed 10μ.

If we take the unsharpness of the normal x-ray image as 1 mm. (this is already low when the indirect method is concerned), after being reduced fifteen times the unsharpness in the reduced image is approximately 0.07 mm. = 70μ. The requirement that the size of grain shall be small as compared with the other unsharpnesses is thus met.

In regard to faults due to imperfect lens correction, we must be more careful. The data measured in the case of two very good lenses are shown in Table I. The circle of confusion was measured by the Foucault method and an effective value established as well as possible. This effective value is then about the same as that calculated from the resolving power, which is determined by the maximum density of lines visible in the photograph of several wire meshes. This density of just visible lines is also indicated in Table I. The Xenon lens shows rather strongly the phenomenon known as coma, as a consequence of which the number of visible lines in the corner of the field is not greater than with the Sonnar, although the effective circle of confusion is much smaller.

It follows from the Table, that the lens' faults alone produce an unsharpness of the same order as that which would occur with ideal reproduction. Lenses with considerably greater errors in correction would be useless. When examining a lens for this special purpose the tests should preferably be made in light of the color of the screen itself. The best thing to do is to work directly with the fluorescent light, for slight deviations in color may have a considerable effect on the lens correction, as lenses are usually corrected for two very definite colors and often show considerable deviations for other colors. Thus, for instance, the circle of confusion in the case of the above-mentioned Sonnar lens was about twice as great in blue light as in white light.

Figure 2 gives an example of an exposure of a number of wire meshes to establish the resolving power or the degree of unsharpness, of the lens-screen combination. Here the wire meshes are laid on the fluorescent screen so that the latter serves as an illuminant. If the meshes are placed behind the screen so that the x-ray image of the meshes are photographed, the same method may serve for establishing the unsharpness of the screen.

TABLE I

	Relative Aperture	Mean Effective Circle of Confusion		Visible Number of Lines per mm. in Reproduction of Wire Mesh	
		Approximate Axis	In Corner of 24 × 32 mm. Field	Approximate Axis	In Corner of 24 × 32 mm Field
Sonnar	1:1.5	30μ	50μ	30μ	20μ
Xenon	1:1.5	20μ	30μ	40μ	20μ

4. *Most Favorable Conditions for Indirect Exposures.*—After what has been stated heretofore, we can now draw some further conclusions regarding the most favorable conditions for making indirect exposures.

In the first place, we find that the aperture of the lens when maintaining the conditions of sharpness, must be as large as possible, as this magnitude, according to Formula 3, determines the brightness of the reduced image and, according to Formula 4, the sharpness of it.

As the unsharpness of the lens is of the order of 30μ and the grain of the film can easily be maintained under this value, we may require that for the degree of photographic reduction used the reduced unsharpness on the film shall amount to a few times 30μ. If this were not so, the unsharpness of the lens would have an unfavorable influence. Now by utilizing the standard miniature size of the Leica, Kodak Retina, Contax, etc., the size of the film is about 24 × 32 mm.[2] This signifies that an image 30 × 40 cm. would be reduced 12.5 times in order to become this

size. An unsharpness of about 1 mm. on the screen must be reckoned with, so that the reduced unsharpness would amount to 80μ. The figures show that the size of 24 × 32 mm.[2] is large enough to produce all the details present in the radiograph, provided the lens unsharpness does not exceed 30μ. In regard to grain, even the sub-standard film is preferred by Russell Reynolds (7) in his cinema technic. It must be observed, however, that at least in regard to stationary images, the grain is already troublesome, causing an annoying effect during observation. This effect is considerably less in cinematography. However, in the case of these very small radiographs, the faults of the lens begin to become serious unless special lenses are used, having a circle of confusion in the whole image not exceeding about 10μ.

Finally, we can determine from the above considerations approximately the best exposure conditions for a lens of an aperture $f/1.5$. Taking, as example, a lung at a distance of 90 cm. lens–screen. Abreu (2) and Holfelder (8) recommend focus–screen distances of, respectively, 60 and 70 cm. and arrive at the following exposure conditions: size, 24 × 32 mm.[2]; tube voltage, 80 kv. peak; focus of the Rotalix tube, 2 mm.; Agfa Isochrom film; a zinc sulphide screen with an unsharpness of approximately 0.6 mm.; time, 0.1 sec.

Figure 3 shows a lung radiograph taken under the above conditions with an $f/1.5$ lens.

SUMMARY

The indirect radiograph, obtained by means of a reduced picture of the screen image with a lens, is compared with the direct exposure. The result is that, with approximately equal contrasts, the unsharpness of the indirect method is approximately $\sqrt[3]{I/I'}$ times greater than in the case of the direct exposure, when I/I' is the ratio of the light intensity, I, in the large image to I', that in the reduced image. This ratio can easily be calculated from the aperture d/f of the lens, *viz.:*

$$\frac{I}{I'} = 16\left(\frac{f}{d}\right)^2.$$

The lens must, therefore, have as large a relative aperture as possible without the reproduction faults exceeding the indicated limits.

The photographic quality of the indirect image is approximately equal to that of the direct image (ordinary technic) when for the indirect image a tube with a rotating anode is used and for the direct image a tube with a stationary anode.

The most suitable size is approximately that of the miniature camera, 24 × 32 mm.[2], when a lens is used with an effective circle of confusion not larger than about 30μ.

The conditions are indicated under which with a lens having a relative aperture of $f/1.5$ and the application of the rotating anode, approximately the most favorable exposure is obtained.

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COLLECTIVE FLUOROGRAPHY[1]

By DR. MANOEL DE ABREU, *Rio de Janeiro, Brazil*

From the Medical Academy

TWO methods of x-ray analysis have been available for the thoracic survey of large groups of individuals. One, radiography, is expensive and impractical, while the other, fluoroscopy, requires the services of a considerable number of skilled specialists (about 150 per million examinations per annum).

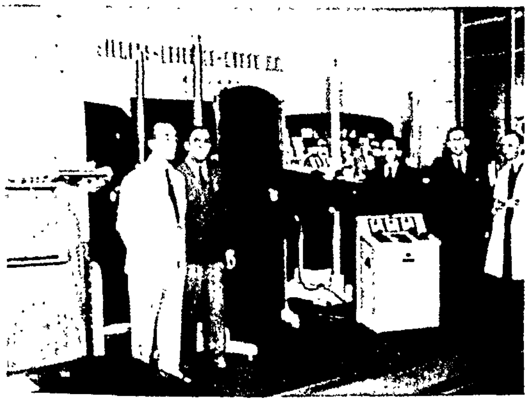


Fig. 1. The first collective apparatus, installed by Dr. Manoel de Abreu in May, 1936, at the Hospital Allemão, Rio de Janeiro.

The method of fluorography or fluoroscopic screen photography, or indirect radiography, which has also been called roentgen photography, does, however, permit practical chest surveys of large groups effectively and at a low cost.

Indirect radiocinematography, an expensive method, is still in the experimental stage and may eventually be useful for certain types of research and teaching, but it is not to be confused with the method of roentgen photography utilized by the writer for tuberculosis prophylactic surveys.

Though fluorography was attempted long ago by many workers, the early results were unsatisfactory. Blyer (1896), MacIntyre, Porcher, Köhler, Lomon and Comandon, Cole, and others experimented with the method. In 1918, and later, in 1924, we attacked this problem diligently but were unable to obtain decisive or practical results. Then most of the work was directed exclusively to the solution of the problem of radiocinematography. More recently this has been accomplished by Reynolds, Djean, and Janker.

Fig. 2. One of the first films obtained by collective fluorography in May, 1936. Large infiltration on the right side and slight infiltration on the left.

We inaugurated the first installation of fluorographic apparatus for the purpose of carrying out a collective thoracic survey at the German Hospital of Rio de Janeiro, in 1936; thus our priority cannot be contested.

In 1937 three additional centers were operating, one in the Public Health Department of Rio de Janeiro, one in the Navy Hospital, and one in the Public Health Department of Victoria.

At present,[2] due to the great interest

[1] This is one of a series of papers contributed by friends and former pupils of I. Seth Hirsch, M.D.

[2] Early in 1939.

aroused by this work, we have 25 installations in Brazil and many others in Argentina, Chile, Uruguay, Germany, France, etc. The method has also been carried to the United States by Dr. D. O. N. Lindberg, of Decatur, Illinois, who, after his visit to us late in 1937, introduced fluorography in his sanitarium. Our attempts, in 1937, to interest American manufacturers in the construction of this apparatus were unsuccessful.

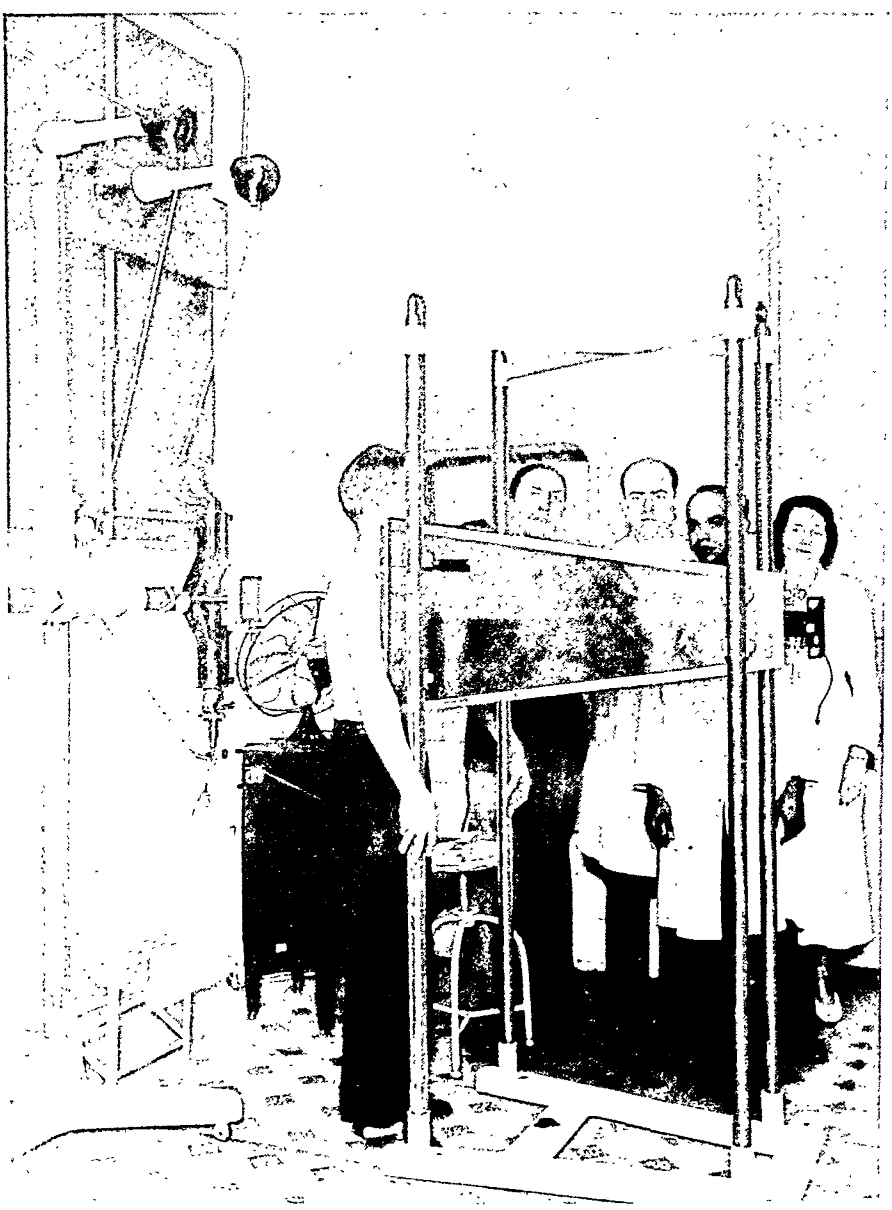


Fig. 3. Roentgenphotographic apparatus "Manoel de Abreu" at Rio de Janeiro Public Health Department (June, 1937).

To-day, three years after the first practical results were achieved, collective fluorography is universally accepted. At the beginning of this work, there were many roentgenologists who expressed themselves in opposition to the procedure but have since become convinced as to its practicability.

The objections with which we had to contend at the beginning were principally that since the initial roentgenological indications of tuberculosis are frequently very vague, fluorography would not show sufficient detail to demonstrate early tuberculosis, and that fluoroscopy in various planes was essential to diagnosis. Also, the wear and tear on x-ray tubes from the exposures on a large scale would make the procedure expensive.

In answer I quote from Professor Hans Holfelder (Introductory remarks of Professor Holfelder (17); "The present work of Dr. Abreu deserves the most widespread attention in the consideration of the question of a large-scale campaign against tuberculosis, since, for the first time in practice, a means has been found which, in my opinion, is capable of settling the problem of the proper position of roentgen diagnosis in the battle against tuberculosis." (*Fortschr. a. d. Geb. d. Röntgenstahlen*, 58, 183, 1938.)

From our eminent colleague, Dr. R. Vaccarezza, President of the Argentine League Against Tuberculosis, we have received a communication from which we quote the following: "My gratitude was greater for having had the opportunity of learning your roentgen photographic method which I studied closely. Its application in social work I consider one of the greatest medical conquests of recent time." (Aug. 2, 1927.)

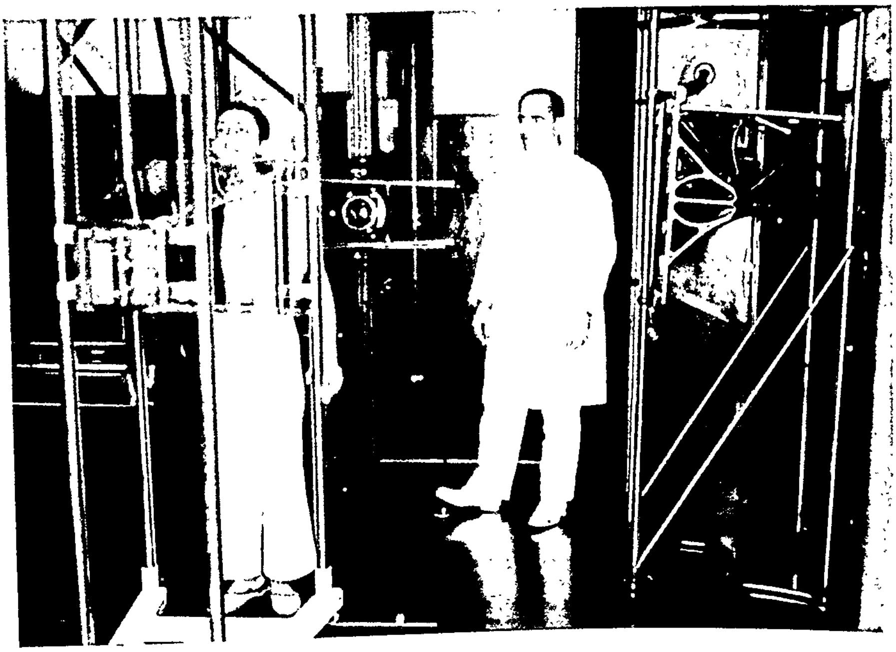


Fig. 4. The roentgenphotographic apparatus "Manoel de Abreu" at the Marine Center of Rio de Janeiro (August, 1937).

The technic used in the beginning of our work was as follows:

1. Four-valve rectifier apparatus.
2. Water-cooled 10 kw. line focus tube.
3. G. E. Patterson screen or Siemen's Super-astral screen without yellow varnish.
4. Objective Zeiss F 1.5.
5. Objective screen distance 90 cm.
6. X-ray tube—screen distance 60 cm.
7. Film, 35 mm. Agfa Isochrome F (28 Sch.).
8. Adult average chest, 50 ma., 80 kv., from 0.3 to 0.4 second.
9. Children, 100 ma., 100 kv., from 0.03 to 0.05 second.

Under these conditions, 35,000 fluoro-

graphs were made at the Public Health Department without damage to the tube.

Later modifications introduced are:

Fig. 5. The four-column apparatus built at the beginning of 1937, and inaugurated at the Health Department of Rio de Janeiro in June, 1937. Observe the special "collective" camera.

1. Kodak Super XX film (32 Sch.) or Agfa Isopan I.S.S. (31 Sch.).
2. Average adult chest, 50 ma., 55 kv., from 0.2 to 0.3 second.
3. Children, 100 ma., 50 kv., from 0.03 to 0.05 second.

With half wave apparatus, without rectification, we advise 70 kv., leaving the other factors unchanged.

The 35 mm. film size is preferred because it is easily available and inexpensive (about one cent per record). We are convinced that the small image, 2.4 cm. square, has a perfection of detail completely adequate for a diagnostic survey. Teleradiography and planigraphy must often be used as supplements for an individual case.

TABLE I.—COMPARISON OF EXPENSE OF THREE METHODS, FOR ONE MILLION EXAMINATIONS ANNUALLY

Radiography	$900,000
Radioscopy	340,000
Roentgen Photography	112,000

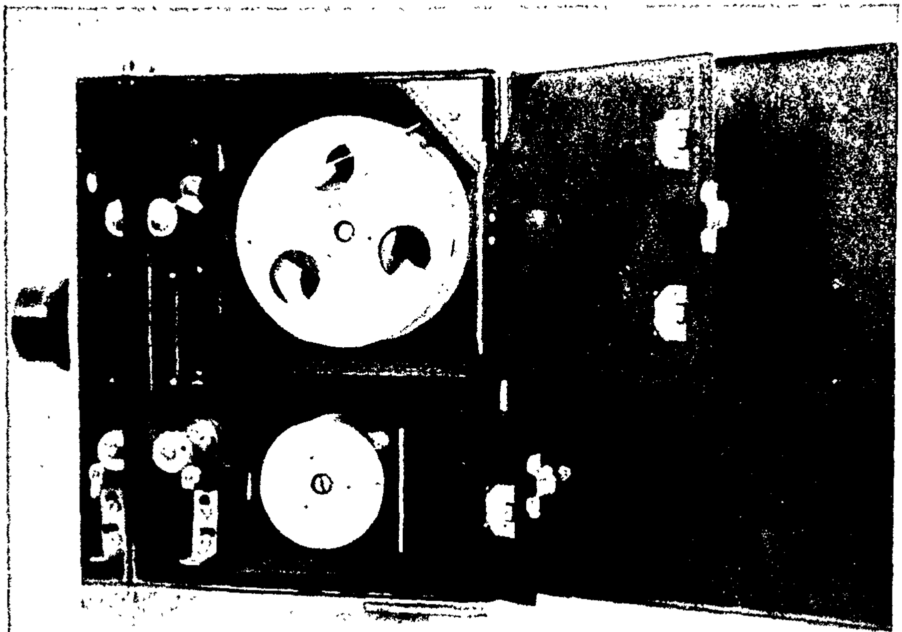
It is erroneous to believe that the greater detail obtainable with instantaneous teleradiography permits a finer diagnosis of tuberculosis. Our investigation of the limit of visibility of pulmonary lesions indicates that such visibility is mainly determined by radiogeometry, that is, by the angle of incidence of the radiation on the surfaces bounding different densities. If the incidence on the surface of a lesion is parallel or tangent, the visibility is clear; if, however, it is oblique or transverse with an obliquity greater than 22.5 degrees, the images are faint or may even vanish. Thus, in the best teleradiography, processes having a volume from 20 to 100 c.c. are not visible. We believe that frequently roentgen photography at various angles, such as anterior and posterior descending directions, has the advantage over teleradiography of showing faintly visible or invisible lesions.

The diagnosis of all or almost all cases of pulmonary tuberculosis by means of roentgen photography will assist in directing the social campaign against tuberculosis to meet the threat presented by the individual. The hazard, according to our conception, is dependent upon the relation between afflicted persons and children or adolescents.

The categories of decreasing hazards are three: (*a*) permanent contact (common domicile); (*b*) indirect or transitory contact; (*c*) absence of contact.

The approximate data for the city of Rio de Janiero are shown in Table II.

Thus, among the 687,000 persons living together with children, 2 per cent suffer from disease (13,740). Of these, 5,000 are parents, 3,750 servants, and 5,000 relatives and friends. The females among these—mothers, servants, and relatives—present the greatest hazard due to their close intercourse with children. The scale of hazard is as follows: mothers, 4.4.; female servants, 4.25; female relatives, 2.8; fathers, 2.8; male servants, 2.66; male relatives, 2.



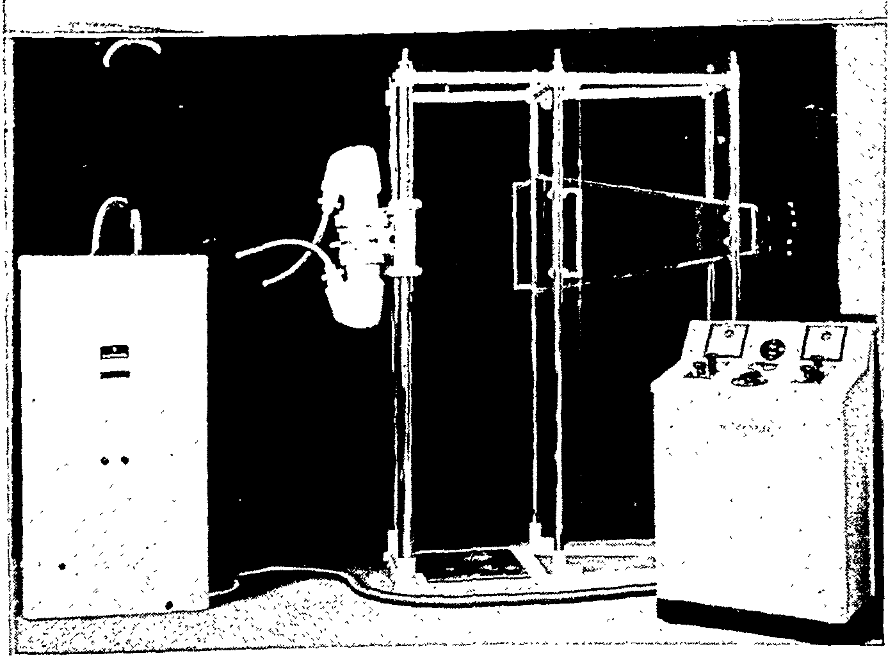


Fig. 6. The special "collective" camera used since 1937, with the 60 mm. film bobbin.
Fig. 7. The latest type of collective fluorographic apparatus with six columns, built in 1938, first installed at the Assistencia Municipal, Rio de Janeiro.

The legislative measures which would

assure this campaign for a general survey should be based on the health examination already obligatory for those employed in certain occupations (collective). It would

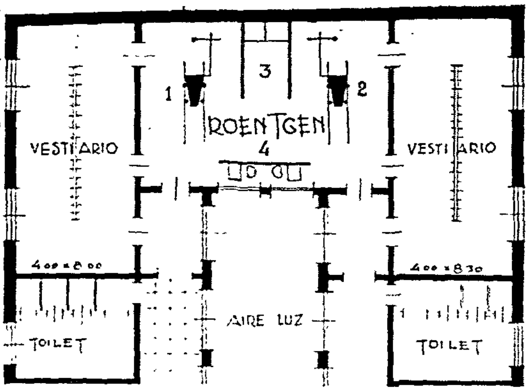


Fig. 8. The Argentine Center of Thoracic Census with two roentgenphotographic apparatus "Manoel de Abreu," under Dr. Vaccarezza's direction, to be inaugurated in Buenos Aires, May, 1939. 1 and 2, apparatus; 3 and 4, x-ray protectors.

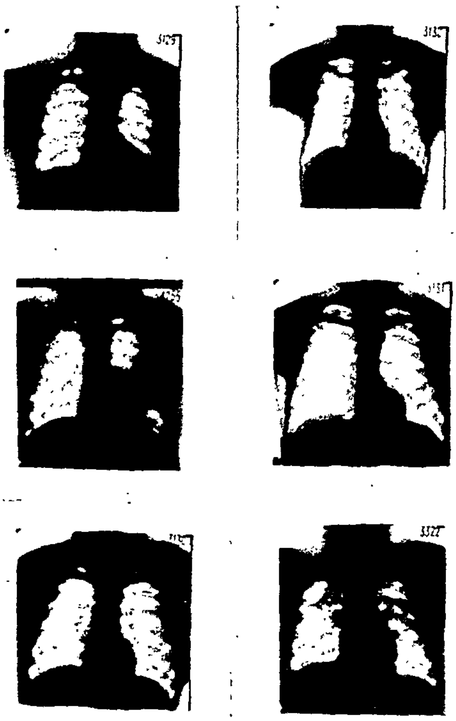


Fig. 9. Fluorographic prints, natural size.

be sufficient if such health examinations were: first, required periodically with roentgen photography; second, extended to all workshops, homes, teaching, and sport centers; third, required not only of workmen, soldiers, teachers, students, and

TABLE II

Population	2,000,000
Minors	500,000 (25%)
Homes with children	125,000 (4 children each)
Parents	250,000 (2 to each home)
Servants in general	187,000 (1.5 per home)
Other adults in homes	250,000 (2 per home)
Total number of adults in homes	687,000 (5.5 per home)
Tuberculosis mortality	7,000 per annum
Number of tuberculous persons	40,000 (5.7 × mortality)

sportsmen, but also of members of their respective families and people sharing their homes.

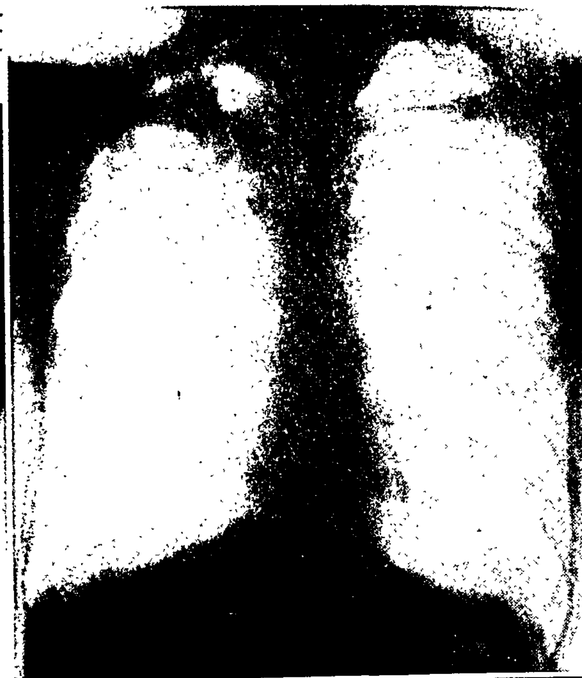
In this way there would be established a new and efficacious campaign against tuberculosis—a center for complete thoracic survey. Such a center should be equipped with social and statistical service and three roentgen photographic installations capable of completing 3,000 examinations daily, or 85,000 per month, or about 1,000,000 a year.

The thoracic survey center should, in addition to making the diagnosis, have control of all persons either tuberculous or suspected of being infected with the disease. Unknown tuberculous persons would then disappear. The social status of those individuals who present a hazard and of those who are menaced by exposure would be known to the health authorities. The thoracic survey would permit early diagnosis by means of roentgen photography of all the population and enable the dispensaries to operate with the utmost efficiency.

Systematic prophylaxis would at once solve the problem regarding suspects in our homes (servants and friends) who number 4,375. These persons would, without any expense, be summarily withdrawn from homes with children and adolescents. There would remain 2,500 tuberculous

parents with 5,000 children threatened or already infected. In this group, the children as well as their parents must be cared for with our present and future facilities.

The sanitation and prophylactic system based on hospital dispensaries failed, because a complete thoracic survey has until now not been made. Tuberculosis pro-



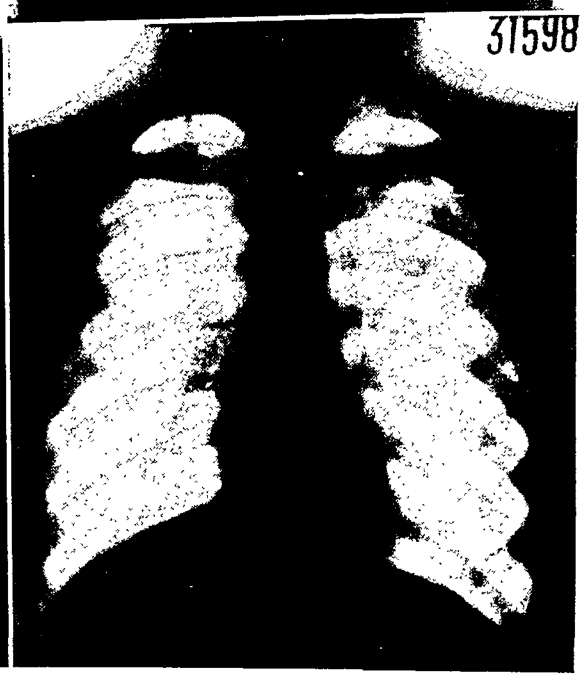


Fig. 10 (*upper left*). Enlarged fluorography. Infiltration in the region of the small right interlobar fissure. The left lung shows a small cavity between hilus and costal borders.

Fig. 11 (*upper right*). Fibroid tuberculosis of the upper right lobe. Undiagnosed, but discovered by the chest collective examination.

Fig. 12 (*lower left*). Left pneumothorax. The collapse therapy control at the Health Department of Rio de Janeiro is done only by fluorography, in two views: postero-anterior and right or left oblique.

Fig. 13 (*lower right*). A cavity in the upper right lobe. Another case of undiagnosed tuberculosis discovered by the collective examination.

phylaxis cannot be secured by treatment and isolation of a small percentage of tuberculous persons. On the contrary, it would be based on the discovery of all infectious foci followed by the isolation of all dangerous persons and protection of all those threatened and in a receptive condition.

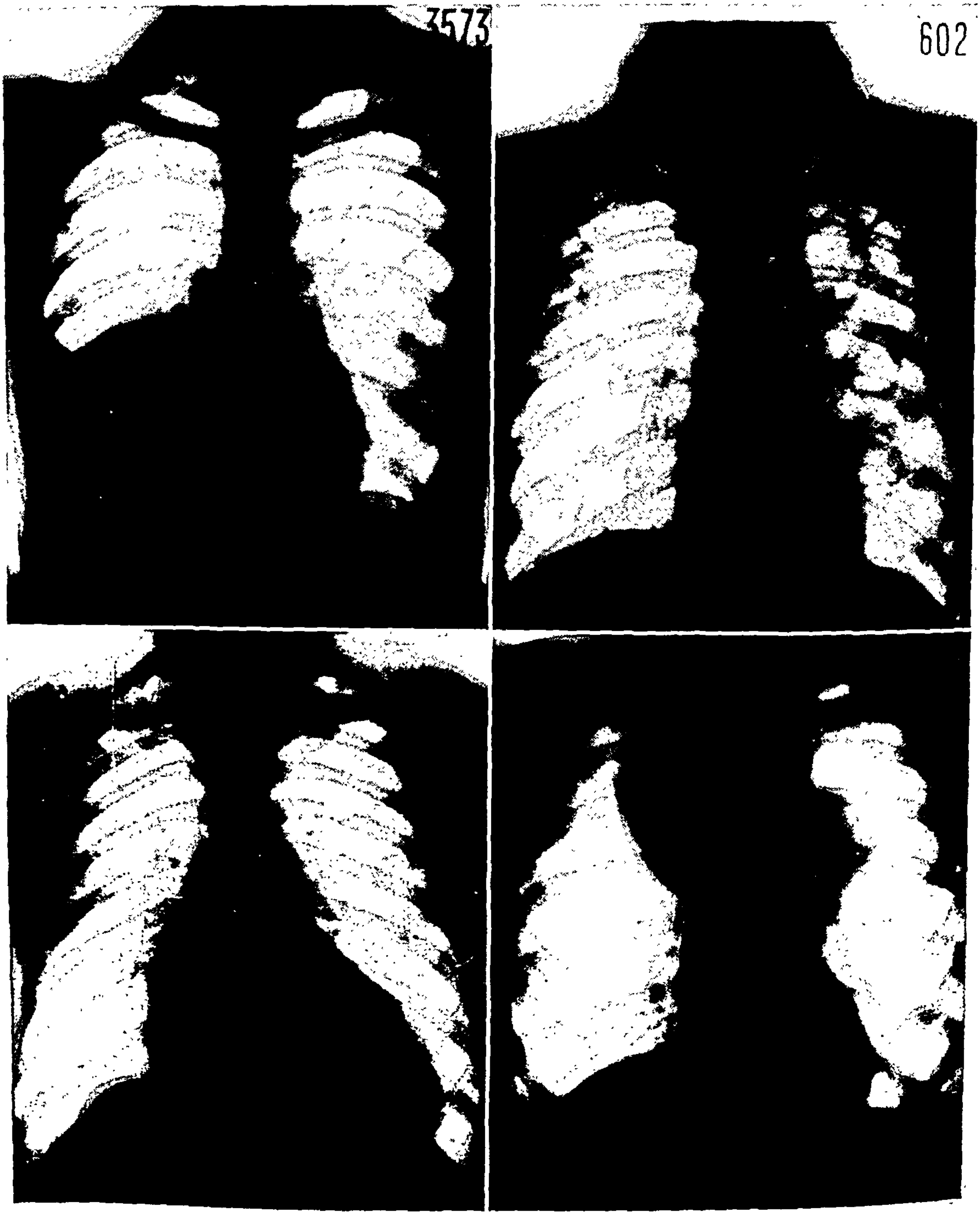


Fig. 14 (*upper left*). Consolidation at the right base.
Fig. 15 (*upper right*). Multiple cavities in left lung. Discrete foci on right side.
Fig. 16 (*lower left*). Aortic insufficiency; hypertrophy of the left ventricle.
Fig. 17 (*lower right*). Aortitis and large aneurysm of the ascending aorta revealed by collective fluorography.

We add that, in addition to tuberculosis, we simultaneously check the cardiovascular system, having in view the frequency of syphilitic aortitis in Brazil.

Systematic fluoroscopy as a control in collapse therapy has been abandoned by us and replaced with advantage by fluorography prior to insufflation. The description of the new method may be found in our book published early in 1938 (14).

Finally, we employ fluorography with planigraphy; in this way we can take a great number of sections at various angles with no expense.

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THE SPHINCTERS OF THE COLON[1]

By PROFESSOR R. BALLI, Radiologist, Royal University, *Modena, Italy*

Translation by Theodore R. Frattalone, M.D., New York City

THE study of the sphincters of the colon, concerning which radiologists have contributed considerable data, is important from an anatomical, physiological, and pathological aspect.

From an anatomic and histologic standpoint, according to findings which I have previously presented, the sphincters of the colon are as shown in Figure 1.

(*A*) *Sphincter of Varolio* (Fig. 1-*a*).—Rutherford (1904), using anatomic specimens of animals which had succumbed to a violent death and of human cadavers (a few hours after death), was able to demonstrate that the ileocecal valve, in the fresh state had a very different aspect from that which the anatomist had described, that is, the ileocecal valve presented itself as a spherical eminence lacking a valve and frenula. The anatomic structure of this eminence, according to Rutherford, consisted of two layers of muscular fibers, circular and longitudinal, originating from the small intestine, an external third layer of circular fibers which formed a true sphincter, and, lastly, an internal fourth layer also made up of circular fibers (circular muscle layer of the mammillary eminence). At the apex of the valve these three circular layers unite in a single stratum of circular fibers.

I have been able to confirm Rutherford's findings and also to show that there are fibers which originate from the innermost layer of longitudinal fibers as above described, which, running an oblique course, meet the circular strata of the mammillary eminence where these terminate. Beside these of small intestinal origin, there are other fibers, also running obliquely, originating from the innermost part of the longitudinal fibers of the large intestine, which merge with the circular layer of the mammillary eminence. We shall refer to this when we consider the physiology of the sphincters.

(*B*) *Sphincter of Busi* (Fig. 1-*b*).—The sphincter of Busi is placed between the cecum and ascending colon, underneath the sphincter of Varolio. There is, in this area, an increase in longitudinal and circular fibers with a passage of fibers from the longitudinal layer to the circular layer. The vessels in this sphincter, as in the other sphincters, pass from the longitudinal to the circular layer to reach the submucosa and the mucosa.

(*C*) *Sphincter of Hirsch* (Fig. 1-*c*).—This sphincter, which is generally found in the proximal segment of the ascending colon, presents anatomically a complex of longitudinal and circular fibers of much heavier caliber than is present in the sphincter of Busi. The circular layer is reinforced by fibers placed in a ribbon-like fashion.

(*D*) *Sphincter of Cannon-Boehm* (Fig. 1-*d*).—This sphincter is found in the transverse colon at the junction of the proximal and middle thirds. However, it may vary in position in the same individual, and, therefore, one may assume the sphincter to have a relationship to the superior and inferior mesenteric plexuses. It presents no special muscular pattern.

(*E*) *Sphincter of Payr and Strauss* (Fig. 1-*e*).—This is found at the splenic flexure of the colon and does not present any histological difference in muscular structure from that of the colon proper.

(*F*) *Sphincter of Balli* (Fig. 1-*f*).—This sphincter, discovered by Balli, is found at the point where the descending colon becomes the sigmoid. Histologically,

[1] This is one of a series of papers contributed by friends and former pupils of I. Seth Hirsch, M.D.

it presents a different muscular pattern from that of the colon proper.

(*G*) *Sphincter of Moutier* (Fig. 1-*g*).—The sphincter of Moutier is found in the terminal colon between the pelvic colon and the rectum. This corresponds to the area (described by Beirne) at the level of the third sacral vertebra. Histologically, it is composed of interlaced longitudinal and circular fibers.

(*H*) *Sphincter of Rossi* (Fig. 1-*h*).—This sphincter is situated in the mid-portion of the sigmoid and does not present any particular muscular pattern.

From an anatomical standpoint, my work leads me to agree with the others that only four should have the right to be designated as sphincters because of their muscular pattern, namely, the sphincters of Varolio, Busi, Hirsch, and Moutier. Aloi, however, has found no modification from the normal structure of the colon in the regions of the sphincter of Busi and the sphincter of Rossi. There are thus only three organic sphincters: those of Varolio, Hirsch, and Rossi. The others, the sphincters of Cannon (even Arendt does not admit the existence of a true anatomical Cannon-Boehm sphincter, but indicates it simply as a point of contracture), Payr-Strauss, Balli, and Rossi, because of their muscular structure resemble the general muscular pattern of the colon, are to be called functional sphincters, that is to say, areas subject to contracture, but without any anatomic markings.

Aloi, continuing Balli's study, has verified the disposition of the fibers forming muscular plexuses which are evident in the anatomic structure of the ascending colon and terminal portion of the sigmoid, corresponding to the sphincters of Hirsch and Moutier.[2]

Thus, one is brought to define these constrictions, as the writer has already done, as sphincteric areas of the colon.

[2] There thus remains a difference of opinion between Aloi and the writer only concerning the sphincter of Busi, a discrepancy which, in all probability, is due to the peculiar conditions of the anatomical specimens studied.

According to Aloi, there is no difference in the number and size of the arterial vessels in the regions of the sphincters and the other parts of the large intestine. The author, on the contrary, has found an

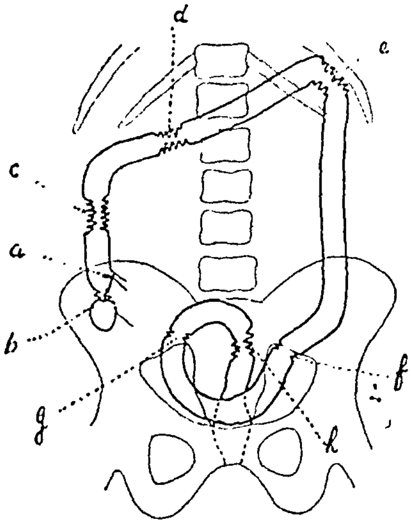

Fig. 1. Showing the sphincters of the colon, starting from the cecum: (*a*) Sphincter of Varolio (improperly called *ileocecal valve*); (*b*) sphincter of Busi; (*c*) sphincter of Hirsch; (*d*) sphincter of Cannon-Boehm; (*e*) sphincter of Payr-Strauss; (*f*) sphincter of Balli; (*g*) sphincter of Moutier; (*h*) sphincter of Rossi.

extraordinary richness of arterial capillaries extending to Auerbach's plexus in the muscular coat and to the plexuses of Meissner in the submucous area. Such an abundance of arterial terminations leads the author to classify these contracture zones of the large intestine as "the true, nerve hilus" of the large bowel, which when responding to stimuli, function actively in the intestinal movement.

From the physiologic viewpoint, credit is due to the radiologists for having studied the movements of the colon. Because of the rich innervation of the sphincteric areas, these react to any local or distant stimulus, be it either intrinsic or extrinsic in origin. The segments of the colon in response to viscero-motor, viscero-sensorial, and viscero-secretory stimuli react by annular spastic contractions in certain zones and thus modify the normal func-

tional activity of the large intestine. The function of these segments will be briefly considered.

(*A*) *Sphincter of Varolio.*—Due to its anatomical structure (Rutherford and Balli) the so-called ileocecal valve has the function of a genuine sphincter. In fact, the oblique fibers, which I have described, must have an influence on the function of this portion of the intestine. After the relaxation of the circular fibers of the sphincter, the passage of contrast substance through the sphincter is due not only to intestinal peristalsis, but also to the contractions of the oblique fibers. The sphincter of Varolio viewed from this standpoint has the function of regulating the passage of chyme from the ileum to the large intestine and impeding its reflux.

(*B*) *Sphincter of Busi.*—According to Busi, this sphincter does not generally contract as soon as the injected material has reached the cecum, but at a later time. It seems to have the function, in the beginning, of facilitating the absorption of material by the cecum, after which the contractions diminish.

(*C*) *Sphincter of Hirsch.*—According to Hirsch, the cecocolic tract acts to prolong the retention of the intestinal contents until cecal digestion and absorption are complete. He believes that the contraction and relaxation of this area of the intestine, analogous to that which happens in the pylorus, is regulated by chemical action.

(*D*) *Sphincter of Cannon-Boehm.*—There are supposed to be two distinct points of activity in this region, both subject to the influence of the nervous system (sympathetic and parasympathetic) which, however, can be stimulated synchronously, giving rise to movements which are well co-ordinated and produce colonic evacuation, or else react antagonistically, with the resultant stasis (ascending colon type).

One area, according to Arendt, shows a contracture formation, while the other area shows a short wave movement with antiperistalsis. The fine nerve connections among the inferior intestinal nerves, the renal nerves, and the pelvic nerves would explain the frequent propagation of stimuli from one organ to another. The contracture phenomena may show itself with or without enteric disturbances or, as a result of such lesions, as gastric ulcer, duodenal ulcer, and renal colic. There are no physiological data concerning the other sphincters.

Sphincters of the Colon in Relation to Some Abdominal Diseases.—Spasm of the sphincteric areas in the colon may be intrinsic or extrinsic in origin. I intend to consider briefly certain conditions, which can, at a distance, produce sphincteric spasm.

(1) *Dolichocolia.*—This abnormally long colon may be acquired or congenital. Some believe it to be congenital, but aggravated by the stasis and associated inflammatory changes. It is sufficient to state that following inflammatory changes with stasis and meteorism, spastic syndromes usually are found in those parts which show altered neuromuscular function and an inflamed mucosa. This does not mean that other areas of the colon cannot be involved. In cases of dolichocolia, I have observed spasm of the Payr-Strauss sphincter (splenic flexure).

(2) *Stypsis.*—The study of the various forms of constipation is very interesting even from the standpoint of differential diagnosis which can be made, radiologically, between true functional constipation and constipation due to extra-intestinal causes.

Radiological research in adults (Balli) and infants (Rossi) of the various forms of stypsis, as I pointed out at the Stockholm Congress, is of importance in the study of such conditions. I have encountered spasm of the Balli sphincter and the sphincter of Hirsch in cases of constipation; in others I have noted only a spasm of the former, and, in still others, spasm of Moutier's sphincter and the sphincter of Rossi.

(3) *Colitis and Pericolitis.*—The chapter on these lesions is of the most complex

of all abdominal pathology. The various types due to diverse causes give similar radiographic pictures. There are also simple irritative states which give etiological radiographic findings more or less similar to each other or altogether identical. In these forms, the spasm involves that portion of the colon which is affected by the morbid process. The corresponding sphincter in this area may become involved. Thus, the same may be said for pericolitis, in which for example, due to the presence of Jackson's membrane, there can be a spasm of Hirsch's sphincter (Hirsch and Balli) or a spasm of Busi's sphincter (Balli).

(4) *Diverticulosis and Diverticulitis.*—The study of diverticulosis and diverticulitis has assumed, in these past years, a great importance especially to the radiologist. The discussion concerning the sphincteric reaction in cases of diverticulitis, which we have been able to find reported in the literature, is not generally dwelt upon by the authors who describe abscesses, fistulæ, and peritonitis following the perforation of the diverticuli; or pericolitis, which, stenosing the intestine, may simulate constrictions due to neoplasms. Only now and then is there any reference to the phenomenon of spasm which is not infrequent in diverticulitis. Busi states: "The special spastic aspect of a segment of colon resembling an accordion, which simulates very much a dilated segment of small intestine with its valulæ conniventes, can often be found in diverticulitis and can even be considered characteristic."

Radiographically, it is simple to differentiate segments of colon-affected spasms due to multiple diverticulitis and from spasm due to extra-intestinal or other intestinal lesions. The presence of diverticuli, which are evidenced by small rounded shadows, grouped together or isolated, gives a characteristic radiographic picture which is unmodified even in the presence of spasm. The diverticuli in the spastic area stand out sharp and clear. In the majority of cases, the diverticuli are disseminated in large segments of colon and may produce a variety of spasms of the intestinal wall and in more than one sphincter at the same time.

(5) *Tuberculosis of the Colon.*—It is well known that the radiological findings of tuberculosis of the cecum show fixed deformities as a result of tubercular infiltration of the wall, and alterations in the cecum due to the more or less precocious emptying (Stierlin's phenomenon). However, in these forms, the spasm of Hirsch's sphincter (Piccinino) is also found.

In cases of ileocecal tuberculosis and in other tubercular conditions of the ileum, one can see spasms of Hirsch's sphincter (Hirsch, Balli, etc.).

(6) *Chronic Appendicitis.*—It is well known that the diagnosis of chronic appendicitis is given by numerous signs recognized by the radiologists.

In this regard Piccinino, Guidotti, and Perotti's research is quite interesting. According to Piccinino, "Besides the presence of gas in the terminal loops of small bowel, dilatations, hyperperistalsis of the terminal loop and disturbances of motility, inconstant ileal stasis, cecal stasis, initial accelerations of the motility of the colon, with successive delay in emptying, etc., there can be found deformities and spasms of the cecum and persistent contractions of the sphincter of Busi, together with a spasm of sphincter of Varolio. These findings are considered important for the diagnosis of chronic appendicitis."

Hirsch, some time ago, demonstrated spasm in the sphincter which bears his name, in cases of chronic appendicitis, and Busi, George and Leonard, and the writer also noted this finding on numerous occasions; the same applies to cases of appendicitis with adhesions of the right adnexa.

In appendicitis with dense adhesions, spasms of the sphincters of Busi, Hirsch, and Cannon are found simultaneously (Oppenheimer, Balli) and associated spasms of the ileocecal valve in patients in whom a diagnosis of chronic appendicitis was justified, have been noted by Labroche, Brodin, Bonneau, and Carrie.

Guidotti and Perotti (of my school) have studied the state of the colonic sphincters in chronic appendicitis and have found that there is a great accentuation of hyperexcitability of the colon in this disease, and, because of this, the sphincters show a disposition to spasm. They have found Busi's sphincter energetically contracted in all cases of chronic appendicitis which were studied; while the sphincter of Cannon reacted in only half the cases, the contraction being slighter, less diffuse, and limited to the right. The authors state that in one case of appendicitis the sphincter of Busi was contracted to such a degree that the cecum was not filled at all. At the operation, a few days after the radiological examination and 40 days after the acute appendiceal attack, a perforated appendix was found, with a small abscess circumscribed by peritoneal adhesions.

According to these authors, frequent spastic contractions of the sphincters of Hirsch, Payr-Strauss, Balli, and Moutier, and to a lesser extent Rossi's sphincter, may be demonstrated in these cases. The sphincter of Payr-Strauss has shown special sensitivity to contraction, yet this sphincter is located just below the splenic flexura.

(7) *Duodenal Ulcer.*—Sphincteric spasms together with pylorospasm may be found in cases of duodenal ulcer.

(8) *Cholecystitis.*—Guidotti and Perotti studying appendicitis and cholecystitis, by means of barium enemas, point out that credit is due the radiologists for revealing the complicated autonomy of the digestive tube and the existence of the various reflexes (viscero-sensorial, visceromotor). The latter are especially important in our work because of the either increased or decreased motility of the colon that one finds in chronic cholecystitis.

According to these authors, the autoregulating mechanism of the digestive tube can be altered even by lesions of the gall bladder, with functional changes in the contractility of the various segments of the colon. From their study it is apparent that in chronic cholecystitis there is a state of hyperexcitability of the colon as demonstrated by the spastic contractions of various sphincters, induced by means of a tepid barium enema administered with low pressure.

The sphincters of Hirsch, Payr-Strauss, Balli, Moutier, and Rossi appeared to these authors contracted in an equal percentage of cases of appendicitis and cholecystitis (nine out of twelve cases).

Moreover, in some cases of cholecystitis the ascending colon and cecum have shown a diffuse haustration without a true spasm of Busi and Hirsch's sphincters.

Biedermann has demonstrated in cases of cholecystitis with stones a spasm of Cannon's sphincter, and a similar case has come to the attention of the writer.

CONCLUSION

1. The sphincters of the colon, the study of which is the work primarily of the radiologists, may from an anatomic standpoint, be divided into organic and functional types.
2. These sphincters have a notable physiologic importance because they play a part in the complex mechanism of the digestive tract.
3. These sphincters react by spastic contractures to lesions of the various segments of the colon and other abdominal viscera.
4. These sphincters do not necessarily act in the same way with a particular lesion, nor does the same sphincter always react to the same lesion.
5. The sphincteric spasm is not, therefore, a pathognomonic sign of an abdominal lesion, but is only a general sign of irritation.

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CONSIDERATION OF POLYCYTHEMIA AND GRENZ-RAY THERAPY[1]

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DIAGNOSIS AND ETIOLOGY

THE etiology of polycythemia is still a problem, the solution of which has not as yet been found. The standard texts and the literature consider polycythemia under two headings: (1) a pathological physiological response to tissue needs resulting from some peculiarities in the environment, and (2) a disease entity of unknown etiology and fatal termination.

Physiological polycythemia or erythrocytosis may be transient or permanent, trivial or grave, relative or absolute. It may result from a loss of tissue fluids, such as occur in cholera and profuse diarrheas. It may be due to localized concentration of red blood cells in the circulatory channels. It also occurs as a secondary bone marrow hyperplasia due to such conditions as high altitudes. When there are violent and abrupt transactions from sea level to high altitudes, cardio-vascular embarrassment occurs with increased production of red blood cells to compensate for the reduced oxygen tension of the atmosphere. Other circumstances, such as hot and cold baths, massage, violent exercise, and some drugs, following digestion, blood regeneration, vomiting, sweating, removal of exudates, myxedema, acute yellow atrophy, are followed by physiological polycythemia. Conditions of circulatory stasis as they occur in organic heart disease, as, emphysema, stenotic dyspnea, congenital diseases of the heart of the cyanotic type, also are frequently associated with polycythemia.

Under the names of erythremia, erythrocytosis, Vaquez's disease, Osler's disease, polycythemia rubra, and polycythemia vera, polycythemia has been considered as a disease entity. Erythremia is a slowly and intermittently progressive, ultimately fatal disease characterized by erythrocytosis, splenomegaly, and a peculiar red cyanosis with a greatly increased blood volume, hyperviscosity of the blood, a shortened coagulation time, and sometimes hepatomegaly. The etiology is definitely unknown, but familial and congenital relationships have been considered. Reznikoff, Foot, and Bethea reported, in 1935, 135 patients with polycythemia, of whom 48 per cent were Jews born in eastern Europe. This interesting etiological relationship is further brought out by the fact that there is an association between polycythemia and Buerger's disease. Brown, Allen, and Mahoner analyzed 100 polycythemic cases and found that 25 had symptoms and lesions characteristically found in thrombo-angiitis obliterans, and one case was definitely diagnosed as that disease. The pathological histology found in blood vessels of the bone marrow is similar to that found in cases of Buerger's disease.

Erythrocytosis, splenomegaly, and the peculiar red cyanosis of the skin represent the triad of symptoms found in the majority of cases of polycythemia vera. Sometimes bilateral exophthalmos, blurring of vision, dizziness and headaches, gastro-intestinal disturbances, anorexia, vomiting, constipation, hemorrhages, and cardio-vascular symptoms are prominent in the history. The kidneys show albumin and casts, and sometimes moderately raised, or even high, blood pressure is present. It is considered by Brown and Giffen that renal function is slightly impaired. The hematology of polycythemia always shows an absolute increase in blood volume. The red blood cells are increased up to fifteen million and the hemoglobin may go as high as from 165 to 220 per cent, with a low color index. The specific gravity of the blood is always high but since the serum

[1] This is one of a series of papers contributed by friends and former pupils of I. Seth Hirsch, M.D.

is normal, this is due entirely to the increased number of the red blood cells. The fragility of the red blood cells may be normal or slightly diminished. The oxygen-combining power of the venous blood capillary thickening, probably fibrosis, subintimal and adventitial fibrosis of the capillaries, arterioles, and arteries in cases of polycythemia vera. Controls in cases of secondary polycythemia, aplastic ane-

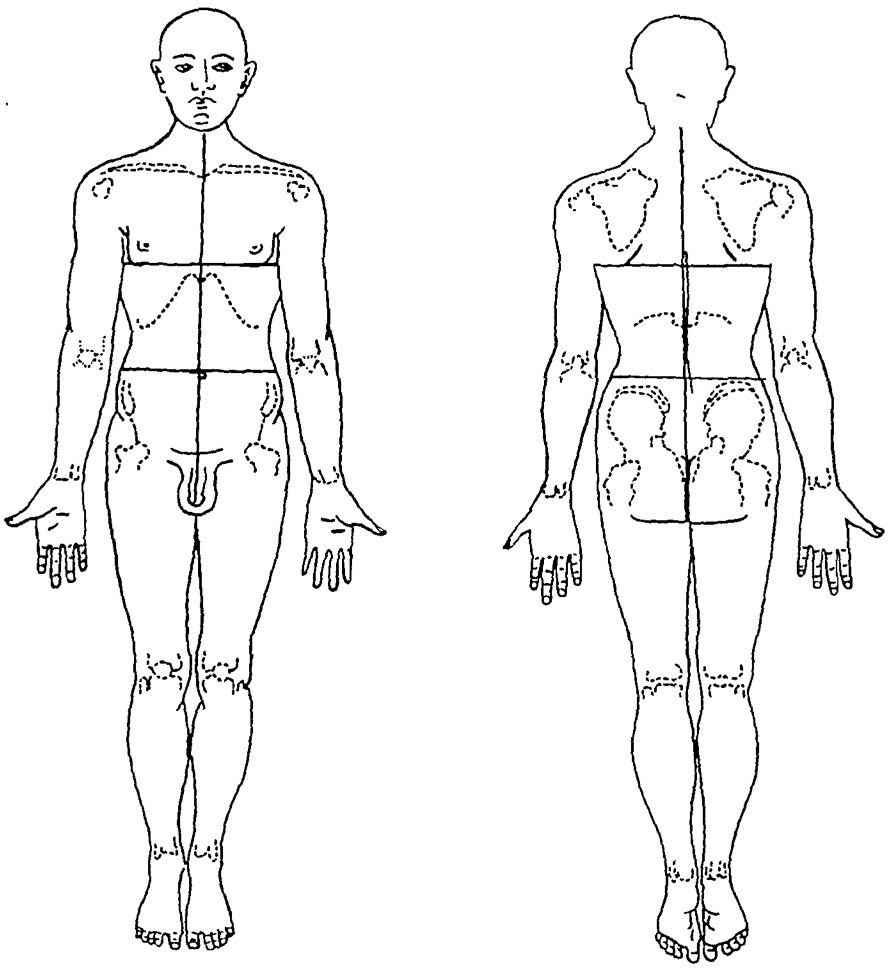

Fig. 1.

is normal, but the venous blood seems to be rich in oxygen. The heart may be enlarged sometimes; the circulation is sluggish but the heart volume output is normal. The red blood cells show anisocytosis and polychromatophilia, and nucleated red cells and myelocytes are found Minot and Buckman showed definite abnormality in the blood smear by the demonstration in all cases of immature forms of red blood cells.

Pathology.—Reznikoff, Foot, and Bethea reported that bone marrow vessels show mia, and aleukemic leukosis were all normal and arteriosclerotic and arteriolarsclerotic controls all showed medial and adventitial fibrosis only.

In the polycythemia cases, occasional thrombosis of small arteries was found, fresh and organized. This study demonstrated that in polycythemia vera there is a definite pathological picture of the capillary and arteriolar blood vessels supplying the bone marrow, but whether this is due to the disease process of polycythemia or causative of the disease process is not dis-

cussed in the literature. However, it is considered by Minot that the pathological processes in the small vessels cause a condition of reduced oxygen tension in the bone marrow with a compensatory or overcompensatory hyperplasia of the bone marrow with the production of an increased number of blood cells.

A mild, early case of polycythemia showed acute inflammatory and necrotic lesions along the course of the blood vessels, characterized by cellular exudates which formed perivascular "cuffs" and some capillaries showed thickening in the midst of pronounced inflammatory lesions. The exudates consisted of lymphocytes and monocytes caught in the migratory, elongated phase. There were a few neutrophiles which rarely formed miliary abscesses. Brown and Giffen studied the capillary morphology in these cases and found that there was engorgement of the venous limb and collecting venule. The arteriolar segment showed relative contraction or a smaller lumen and occasional engorgement. These authors concluded that the tortuosity depended on the age of the patient and not on the blood volume. They found 65 open capillaries per square mm. of skin surface, whereas the normal is from 15 to 40. They also demonstrated that the capillaries came back to normal with reduction of the blood volume. There appeared to be, in polycythemia, a complete utilization of all the capillaries. Return to normal occurred when the blood volume was reduced from 166 c.c. per kilogram of body weight to 110 c.c. Brown and Giffen consider that the thrombotic processes result from an increase in the viscosity and changes in the vessel wall, and changes in the coagulation factors of the blood.

Changes in capillary walls may be due to strain, metabolic disturbances, and other factors. It is, therefore, difficult to conclude from this study whether the changes in the capillaries, which may be due to pre-existent disease, are the cause of polycythemia or the direct result of the pathological processes in polycythemia and of the changes in the blood due to polycythemia. The clinical sequence of events in polycythemia vera seems to follow the following pattern.

A disease process of unknown etiology causes an increase in the number of red blood cells of the circulating blood. The same disease process, or the changes in the blood due to the disease process, causes inflammatory changes in the capillaries, arterioles, and arteries of the bone marrow. These changes are so similar to those found in thrombo-angiitis obliterans of Buerger that the disease has been considered thrombo-angiitis obliterans of the bone marrow. As the disease becomes more chronic, there occurs fibrosis with or without increase in the red blood cells, with or without remission. The permanency of fibrotic changes in the blood vessels refutes the possibility of a remission in erythrocytosis since the fibrosis should act as a permanent impediment to transmission of oxygen to the cells of the bone marrow and cause permanent reduced oxygen tension in the bone marrow. Remissions are not explainable, therefore, and erythrocytosis does not always occur in polycythemia. After adequate venesection, remissions are induced; yet phlebotomy can only reduce the number of oxygen carriers of the bone marrow and further reduce the oxygen tension, but the bone marrow ceases to produce an abnormal erythrocytosis. It is possible that the fundamental but unknown cause of polycythemia may be the cause of tissue hyperactivity of the erythrocyte-producing cells of the bone marrow and that this tissue hyperactivity is the cause of chronic stimulation of the inflammatory reactions, both acute and chronic, in the bone marrow vessels.

Treatment.—The accepted treatment of polycythemia vera comes under three classifications:

(1) Venesection for the purpose of reducing the blood volume. Stephens and Kaltreider removed from 1,000 to 3,000 c.c. of blood in a few days by repeated phlebotomies of from 200 to 600

c.c. of blood and found that hematological and clinical remissions, varying in duration from two months to two years, occurred. There was no variation in the normal range of reticulocyte reactions. These authors believed that a removal of iron and other blood-building materials which are stored with the hemolytic action of phenyl hydrazine, was responsible. Dameshek and Henstell subjected their patients to venesection of 500 c.c. of blood twice weekly till the hemoglobin fell to between 70 and 80 per cent and the red blood cells to about five millions. Their patients were limited to a low iron diet containing less than 6 mgm. of iron per day. They remained symptom-free from six to nine months and rising values were controlled by a few venesections.

(2) By hemolyzing the excess blood cells with some drugs such as benzene, phenyl hydrazine, and acetyl phenyl hydrazine. Experimentally, Waltner and Waltner showed that cobalt given to animals causes polycythemia, and Mascherpa showed an increased activity in the bone marrow in these animals. Barron and Barron believed that cobalt polycythemia is due to the inhibition by cobalt of the respiratory function of the immature red blood cells. These cells are thrown into the general circulation as mature non-respiring cells, being replaced in the bone marrow by new cells. In animals, the administration of ascorbic acid with cobalt prevented the formation of polycythemia and after cobalt administration, polycythemia was reduced to normal levels. Kandel and Leroy administered ascorbic acid to polycythemic patients and found that it had no effect, either good or bad, on the hemoglobin and red blood cell levels in these patients, especially in the prevention of a return to polycythemic values.

(3) Milani, in 1929, and Pack and Craver, in 1930, reported good results with radiation. In 34 instances, Sgalitzer radiated the whole body with fair results, but no permanent remissions. He applied 25 r for 20 minutes to the whole body for six successive days, followed by a weekly interval of rest, with the course repeated until the red cell count fell to normal, noting the fall in leukocytes and stopping the treatment when they fell to 3,000 per cubic millimeter.

It can be seen from this short review of the subject that although there has been advancement in the knowledge of the pathology and experimental consideration of polycythemia, we have not reached a knowledge of the fundamental cause or a satisfactory treatment in polycythemia vera. It is, therefore, of interest to point out the fact that Grenz rays have produced noteworthy clinical and hematological improvements of long duration and to attempt an explanation for the results obtained in these studies.

It is beyond the scope of this review to go into the technical, physical, biological, and physiological aspects of Grenz rays; it is sufficient for our purpose to be brief in describing their nature.

Grenz Rays.—These rays are electromagnetic oscillations of about two Ångström units which produce characteristic biological and clinical manifestations. Absorption of Grenz rays is almost complete in the skin—88 per cent are absorbed in three mm. of skin and only 12 per cent reach subcutaneous tissues in this instance; while more than 90 per cent of roentgen rays pass through such a layer of skin.

It seems highly probable that the kinetic changes in atoms and molecules are more or less the outcome of radiation, though here we deal with orders of magnitude lying far below those which the biologist explores so freely with his microscope (9). Still, if we may regard such transformations as the antecedents and causes of chemical phenomena, and thus of vital activities, it is evident that to radiation there must be assigned, in theory at least, a fundamental influence on the very life process itself; an influence which often is not limited to a single organ but may embrace an entire system.

Interesting and valuable as the Grenz ray is in dermatology, its action upon

internal diseases is even more striking. It might appear irrational at first glance to attempt the treatment of internal diseases by influencing the skin, but a few theoretical considerations will serve to clarify the situation.

More complicated, but for that reason much more interesting, are those processes which take place in the skin on the one hand, and the autonomous nervous system on the other. Here belongs the projection of internal phenomena upon the skin surface, of which only Head's zones and the condition known as "goose flesh" need be mentioned for our present purpose. It is but natural that reactions taking place in the opposite direction, as when events in the skin are reflected by the internal organs, should be harder to investigate, and it is just this difficulty that has delayed correct interpretation of the consequences attendant upon severe and extensive burns of the skin until very recent times. These include diarrhea and intestinal hemorrhage, which have been ascribed to toxic products absorbed into the circulation from the burned surface, notwithstanding the fact that such symptoms never accompany other sorts of injury with equal tissue destruction. Nor has it ever been explained why analogous effects are not produced in all the other internal organs.

On the other hand, an alternative conception which regards these consequences as an outcome of the autonomic connection between skin and splanchnic system, is supported by a whole series of observations. Perhaps the most important of these is a fall in the leukocyte count. The articles of Glasser, E. F. Muller, Petersen, Emden and Freundlich, and others contain a wealth of material relating to this phenomenon which is too important to be overlooked.

Irritation of the skin by light massage, intradermal injection of any material whatsoever (physiological salt solution or air), and so on, is followed after about ten minutes by a fall of some 20 to 30 per cent of the original leukocyte count; the number returns to normal, however, in the course of from 20 to 30 minutes. It is to be emphasized that this return is a characteristic feature of the drop, distinguishing it from persistent leukopenia. As the decrease of leukocytes in the skin is accompanied by a rise of those in the splanchnic system, transfer from the surface to the interior must take place, and the influence of the autonomic nervous system in this emigration is clearly suggested by the work of Emden and Freundlich. These investigators found that the fall did not occur in a sympathectomized limb, though it could be elicited as usual in the normal member of the opposite side.

As the skin and bone marrow are known to be connected through the autonomic nervous system, the treatment of polycythemia rubra was begun. The most effective therapy for this disorder is roentgen radiation of the long bones, as is well known, on the hypothesis that the function of the bone marrow can be thus inhibited and the production of erythrocytes thereby diminished. Well filtered hard rays are accordingly employed, in order that the greatest possible amount of energy may reach the marrow, and the results of this method are really excellent. But it has been shown that general radiation with Grenz rays will also influence favorably the course of this disease in the great majority of cases. It has been our experience in polycythemia, as in vitiligo and alopecia, that a decisive result is not to be expected from but one series of treatments and the physician should not be discouraged, therefore, if improvement does not set in even after the lapse of several weeks. The first evidence is generally symptomatic (amelioration of dizziness, headache, etc.), and not until later does the diminution in erythrocytes and hemoglobin begin to be demonstrable. Indeed, we have frequently seen a rise in the red cell count and the hemoglobin percentage, and in such cases have achieved complete success only after repetition of the series; in this way we were able

to mitigate the condition of a patient in whom Grenz-ray treatment had been discontinued prematurely because it was thought to be ineffective. It is just this possibility of "repetition until success is attained" that makes the Grenz ray preferable to the x-ray, in which recurrent treatment is definitely barred (Spiethoff). By repeating the series throughout the course of one or two years, we have ultimately relieved most of our patients. In the rather extensive literature dealing with polycythemia, remission has been reported only by Rosin and Weintraut, so far as the writer is aware, and it must, therefore, be an unusual occurrence. Hence, any assumption that alleviation occurred spontaneously in all our patients who were improved can be immediately dismissed; of a spontaneous cure we have been able to find no record.

An attempt to explain the manner in which the Grenz ray acts in this disease leads to interesting considerations. It is still a debatable question whether the excess red cells indicate increased production in the bone marrow or decreased destruction in the spleen. The former hypothesis, which underlies the treatment of polycythemia with x-rays, would appear to have been confirmed were it not that cases have been recorded in which roentgen radiation of the spleen alone has been more or less successful. Nevertheless, it is now generally conceded that radiation of the bone marrow is incomparably more efficacious. As the changes in bone marrow and blood are constant findings, whereas splenic enlargement may not be present, it seems logical to search for the seat of the disease in the marrow rather than in the spleen, and the more so because there is no relationship between the erythrocyte count and the size of the spleen; indeed, the fact that an enormous increase in the blood count may be associated with a small spleen, and *vice versa*, discourages all attempts to implicate the spleen itself. However, the disease has a number of other inconstant and puzzling features. So, for example, ulcerations in the gastro-intestinal tract are not an uncommon accompaniment, and perhaps are more often encountered than the literature would suggest (von Bergmann's dysharmony of the vegetative system). Autopsy discloses no change common to all cases, and it is highly probable that the variable symptomatology is the outcome of functional disturbances in one common center, manifesting themselves now in this organ, now in that, according to its "tone" or "disposition."

Our experience with Grenz-ray therapy corroborates the assumption that polycythemia is associated with a functional disturbance in the autonomic nervous system, which normally should supervise and regulate all activities of the various organs. At the present time this is, in fact, the only possible explanation for the favorable results brought about by these rays, for it is inconceivable that any proportion of them worth mentioning should ever reach the bone marrow, their influence being confined, as it is, to the skin. Hence, the possibility that they work as the x-ray is supposed to act, may be denied. It may still be asked, however, if the Grenz rays may not directly destroy the erythrocytes in polycythemia. The latent period of several weeks which must elapse before any diminution appears in their number is against any such suggestion. Furthermore, the amount of blood actually radiated is insignificant, as the rays penetrate hardly more than three millimeters and the exposed field is but 15 cm. in diameter, while the exposure is brief and the amount of available energy relatively small; whence it follows that a minimal volume of blood is affected by comparatively little radiant energy.

Again, symptoms such as we are accustomed to associate with the destruction of red blood cells do not arise, or at least are not appreciable. One last question is, whether some sort of by-product, or a hormone, perhaps, may not be elaborated in the tissues or the blood, but so far we have seen no evidence to support the suggestion, though we have applied Grenz

rays over large areas in a varied assortment of diseases. Of course, some intermediate substance, something of the nature of histamine, might be formed which would affect the autonomic system secondarily, but it seems far more probable that the Grenz rays exert their regulatory effect on organ function through the skin and the autonomic nervous system, as has already been explained in the section on leukocyte drop and sympathectomy.

Comparison of the treatment of polycythemia with x-rays or Grenz rays suggests certain interesting conclusions. Ludin's idea of influencing the bone marrow directly was plausible enough and appeared to be supported by the results. But though it may be safely assumed that in the case of the Grenz ray any such effect can be excluded, the results resemble those of deep therapy. This might be taken to mean that there are actually two distinct ways of affecting the function of the marrow, since the hard rays act directly upon it and the Grenz rays only indirectly. Whether this deduction be permissible cannot be decided at the present time. At any rate, the possibility remains that the hard rays themselves also have an indirect effect, which is exerted partly or wholly through the skin. Against this, however, may be set the fact that the results of treating the spleen with rays

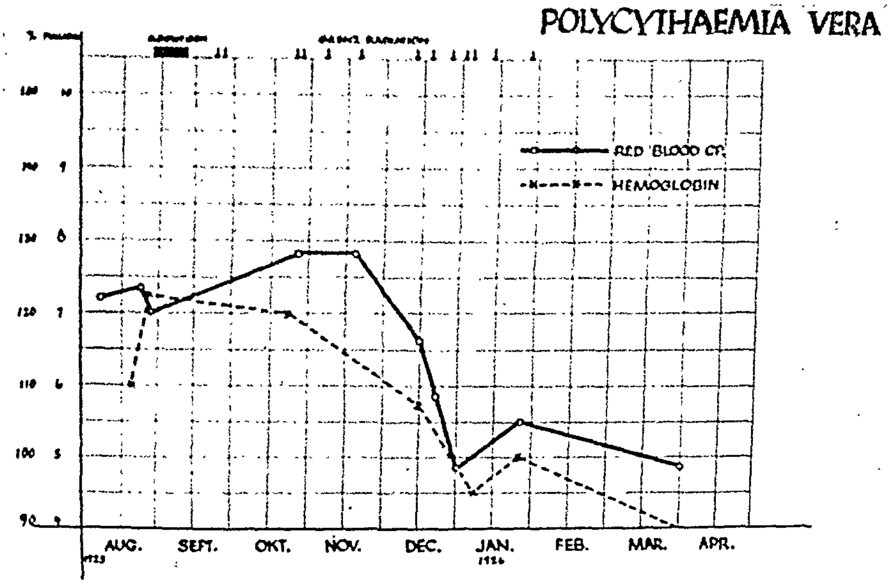

Fig. 2. Case 1.

have been so unsatisfactory as to cause abandonment of the method; still, it must be borne in mind that in treating this organ a smaller field is generally employed than when the exposure is directed at the bones, so that the amount of irritation set up in the skin is correspondingly less. The total dose, too, is smaller. Skin absorption is negligible with hard rays in comparison with Grenz rays, though the difference may be offset to a certain degree by the relatively large doses of x-ray which are required to produce any effect upon polycythemia. It appears to be of significance, also, that only one or two treatments are administered when the spleen is exposed, whereas exposures to the bones are continued for a longer period, so that, as with nonspecific protein therapy, stimulation takes place repeatedly.

The following technic, based upon principles that are still valid, has been em-

ployed from the first. The surface of the trunk is divided into from eight to twelve fields—from four to six on the anterior and from four to six on the posterior aspect—so as to give a right and a left thoracic and a right and a left abdominal area, with corresponding fields on the dorsal surface. Assuming that, as with non-specific protein therapy, the stimulus would have to be repeated and the treatment, therefore, extended to cover a certain period of time, an area was treated daily, so that after the lapse of eight days each had had one radiation. In order to prolong the stimulation, the whole procedure was then repeated, except that now an interval of one day was interpolated between each two exposures. This procedure required 24 days, and one complete treatment of this sort was called a series. A series may be prolonged, if desired, by the inclusion of additional fields (hip, extremities, etc.). It is necessary in most cases to repeat such a series, and it has been our custom to allow an interval of from six to eight weeks before eginning the next one. There is not the htest danger in repetition, for doses are mployed which cause no demonstrable changes in the skin; even a definite pigmentation is seldom observed. Nor is there any objection to administering series after series, if the appropriate intervals be observed, for no damage has ever resulted in cases in which the proper technic has been followed. It seems scarcely necessary to say that the apparatus and the tube itself must be carefully calibrated, for failure or disagreeable consequences may attend faulty technic. Simple though the procedure may be in itself, it must be based upon scrupulously exact dosage, and must, therefore, be supervised by experienced operators.

The best means of measuring the output at the present time is the ionization method, for which a number of reliable instruments are available. The single dose which I have employed amounts, at 15 cm. focal skin distance and with a field about 15 cm. in diameter, to some 150 r; a half absorption value of from 0.0175 to 0.02 mm. in aluminum is to be preferred. In our series, five patients showed definite symptomatic and hematological improvement out of a total of seven, or approximately 71 per cent.

One case made no response to adequate treatment and we could find no explanation for the failure. The other case made no response either, but in this instance, general roentgen radiation had been given. It is usual to find the cases more resistant to Grenz-ray therapy if previously given such treatment.

Case 1. L. B., a 49-year-old houseman (Russian Jew), was admitted to the hospital on Aug. 10, 1925.

His family history was irrelevant. He had typhoid as a child, after which he was not ill for a long time. He smoked heavily. For three months he had had epigastric pressure and pyrosis, appearing every three or four days some three hours after meals. The pain also came at night and when the patient was hungry. It radiated downward to the left. There were severe eructations, loss in weight, constipation, headache, and dizziness. He noted that his face was turning a reddish-blue.

The patient was weak and somewhat undernourished. He presented the characteristic dusky, cherry-red complexion of polycythemia, with cyanotic nose and ears and injected conjunctivæ. The epigastrium was tender, the spleen just palpable. Other physical signs were irrelevant. Roentgen examination showed an irregular descent of the duodenal bulb, diagnosed by Dr. Gottlieb as duodenal ulcer. Blood pressure on Aug. 11, 1925, was 94/66; Sept. 22, 1925, 120/60. Marke traces of occult blood in the feces wer found twice.

The patient could not be persuaded take treatment regularly; therefore, co secutive observations were impossible an the treatment dragged along. After roent gen treatment in August and September the red blood cells increased in numb reaching the peak in November. Onl two Grenz-ray treatments had been give

in September. After the end of October, the patient was more regular in his visits. The arrows indicate the periods of treatment, but not each individual exposure cramps. The family history was irrelevant. The patient had had pneumonia 33 years before, and a tremor of the hands for 30 years, a laparotomy 12 years

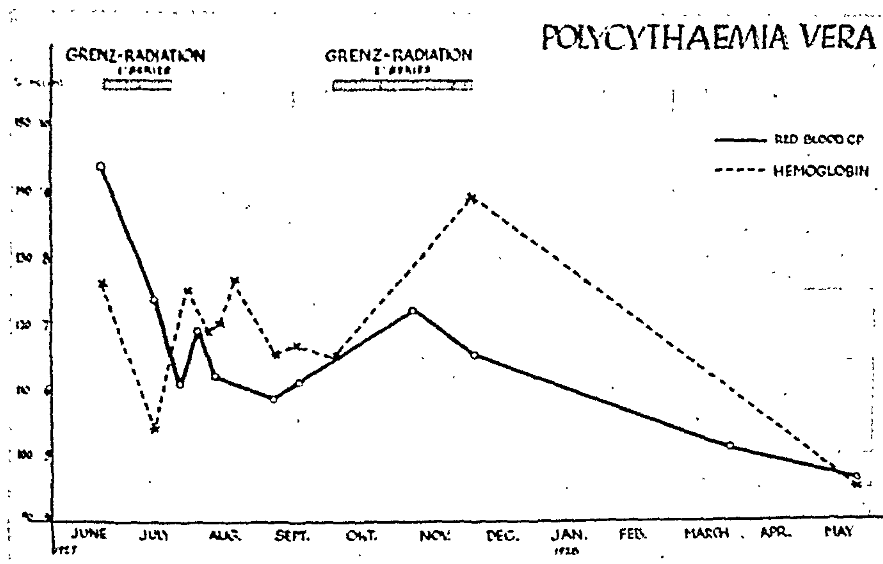

Fig. 3. Case 2.

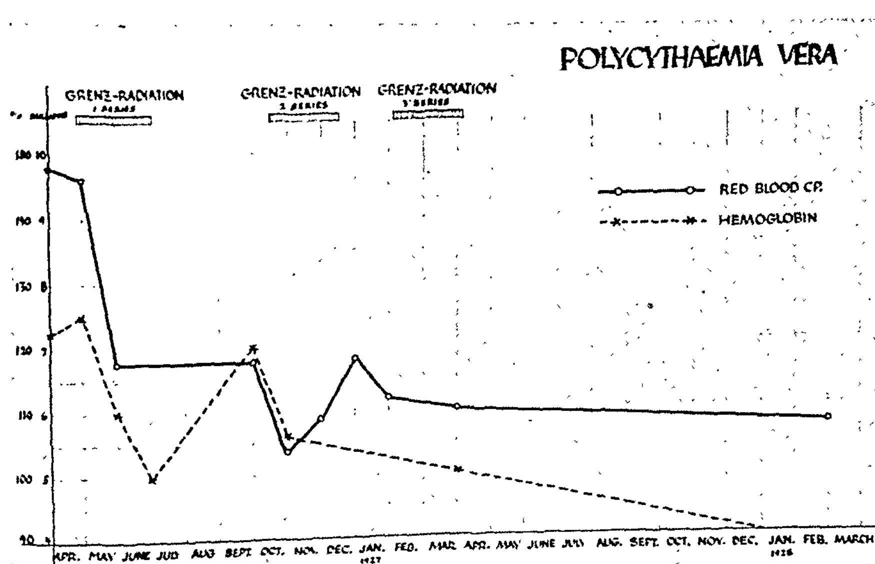

Fig. 4. Case 3.

(Fig. 2). The diagnosis was polycythemia and duodenal ulcer.

Case 2. P. B., a 68-year-old smith (Jewish), had complained of difficulty in evacuating, headache, and abdominal previously, and for 11 years had been unable to work because of weakness. The man was somewhat undernourished, with a slightly blue face. He had no marked disabilities. The pupils were sluggish,

and the pharynx was red. His thorax was barrel-shaped and covered with a maculo-papular rash. Save for a few râles at the right base in the back, the lungs were negative. The heart was

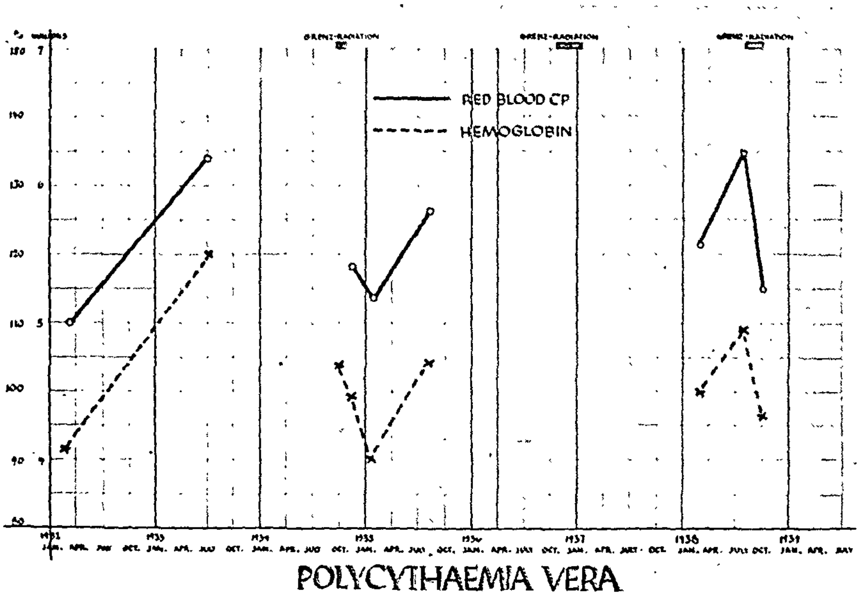

Fig. 5. Case 4.

slightly enlarged as was also shown on roentgen films. The electrograph was normal, and save for palpability of the spleen the abdomen was negative. The reflexes were increased. Hemoglobin was 124 per cent; the red blood cell count, 9,600,000; the leukocytes, 16,000.

Case 3. L. H. S., a 60-year-old Jewish physician, had been ill for seven or eight years. The family history was negative. The patient had had a duodenal ulcer for 15 years. His chief complaints at this time were headache after slight excitement, excitability, loss of self-control, insomnia, sluggishness of the bowels. He was easily fatigued. His left great toe had hurt him for nine months, but the pain had receded during the last three months. His blood pressure was 150/85. The spleen was markedly enlarged, its lower pole reaching the iliac crest. The lips, nose, and ears were blue, the hands red.

There was slight albuminuria with somewhat diminished chlorides and residual ash. The hemoglobin was 125 per cent; red blood cells, 9,400,000; white cells, 12,000. The polymorphonuclear leukocytes were 87 per cent; small lymphocytes, 6 per cent; normocytes, 2 per cent; eosinophiles, 4 per cent, and basophiles, 1 per cent.

About seven years previously, he had had roentgen-ray treatment, starvation therapy, and fruit diet. After the last, the patient maintained that the red blood cells had dropped from 8,000,000 to 4,500,000, but for only eight months. The second series of treatments extended over a protracted period, the patient having been irregular in attendance. He died some years later from pneumonia.

Case 4. The patient, R. P. (Jewish), was seen in 1931, with a history of substernal pressure and pain radiating to the left arm. The physical examination was negative. The blood pressure was systolic, 132; diastolic, 84. X-ray examination of the heart showed normal diameters. Gastro-intestinal examination was negative. The impression at that time was that of coronary disease. The following week tl patient had a definite attack of coron thrombosis which necessitated confinen

to the Beth Israel Hospital for one month.

In February, 1932, the blood count showed the following results: hemoglobin, 91 per cent; red blood cells, 5,000,000; white blood cells, 8,100. In July, 1933, the spleen became palpable. The patient was considered to have a coronary thrombosis, after which a polycythemia vera developed. Figure 5 shows the effect of Grenz rays on the blood count.

Case 5. Mrs. T., a middle-aged Jewish housewife, had been known to have polycythemia vera since 1927. She had been treated with venesections and diet, with poor results. In 1930, she started Grenz-ray therapy and at that time was suffering from dizziness and headaches, and was unable to walk. She had the characteristic red cyanosis and complained of gastro-intestinal symptoms characteristic of ulcer. After Grenz-ray therapy, all symptoms were greatly improved and Figure 6 shows the effect on the red blood cells. She died in 1935. Multiple abdominal and pulmonary thromboses were found, at postmortem examination, which were considered to be the results of polycythemia vera, in spite of the improvement shown symptomatically and hematologically.

The course of the disease and effect of the Grenz rays can be seen from the curves presented (Figs. 2–6).[2] Immediately after treatment there was no change found in the clinical picture. Both subjective and objective improvement set in after three or four weeks. The face grew noticeably paler, the headaches and dizziness gradually vanished. Together with this, the erythrocytes and hemoglobin dropped. There was virtually no effect on the leukocytes.

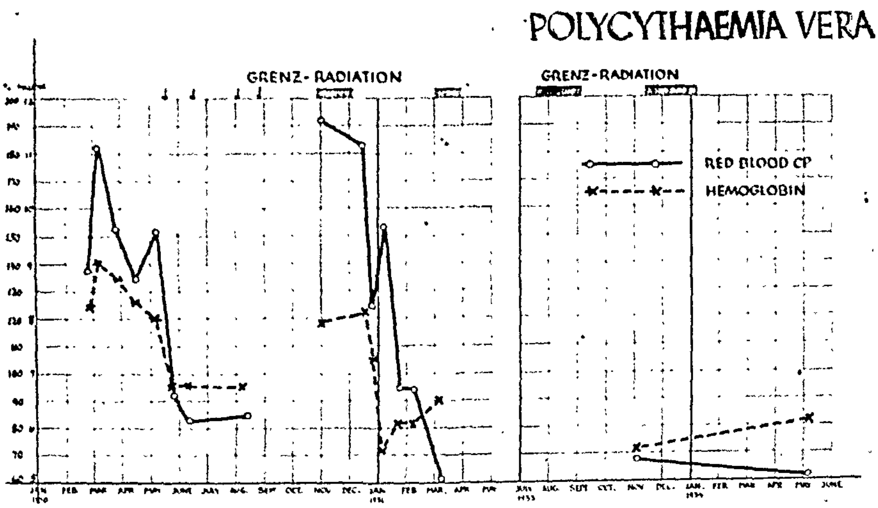

Fig. 6. Case 5.

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[2] A recent case showed the following figures: Feb. 26, 1939, erythrocytes, 8,000,000; hemoglobin, 130 per cent; Aug. 12, 1939, erythrocytes, 4,600,000; hemoglobin, 100 per cent.

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THE IMPORTANCE OF SACRO-ILIAC CHANGES IN THE EARLY DIAGNOSIS OF ANKYLOSING SPONDYLARTHRITIS[1]

MARIE-STRÜMPELL-BECHTEREW DISEASE

By JACQUES FORESTIER, M.D. (Paris), F.A.C.R. (Hon.), *Aix-les-Bains, France*

I

AMONG the chronic diseases of the spine, ankylosing spondylarthritis[2] is one of the most crippling, since its natural result is the complete bony ankylosis of the whole spine. It is a systemic disease which, in its advanced phases, can involve the main joints of the limbs (*spondylose rhizomélique* of Pierre Marie).

The nature of the disease is not yet absolutely determined but it is generally accepted that it starts as an atrophic arthritis of the joints between the facets of the vertebræ (apophyseal joints) which, after an inflammatory stage, become involved by bony ankylosis. Secondarily, there are ossifications of the adjoining ligaments in the ligaments flava, in the anterior and posterior vertebral ligaments, resulting in the classical picture, in the roentgenograms of the bamboo-spine.

The clinical picture in the early stages of the disease is very confusing, which is most regrettable since it is proven that the disease is much easier controlled by treatment at this period, before the advent of the ossifications, than later on when the stiffness of the spine is irremediable. The most striking features of the early period are vague and diffused low back pains, sometimes located in the vicinity of the sacro-iliac joints. Not infrequently an acute attack of sciatica is the only clinical incident which marks the onset of the disease. Still more confusing are the cases associated with radiating pains around the chest or the abdomen which are often mistaken for pleurodynia, kidney disease, intestinal disturbances, uterine retroversion, etc.

The importance of an early diagnosis of the disease cannot be too greatly emphasized. As long as only inflammatory changes are present in the intervertebral joints and even when some purely fibrous adhesions have taken place, ankylosis of the spine can be avoided by effective treatment which has been established in the past years and which can, in most cases, check the evolution of the disease before ankylosis has taken place. But it must be admitted to-day that such an early diagnosis is missed not only by practitioners but even by qualified specialists. It is our experience that over 80 per cent of the cases of ankylosing spondylarthritis that have come to our observation in the past three years, before the beginning ossifications in the spine, have not been diagnosed as such. Most of them were labelled sciatica, muscular rheumatism, lumbago, colitis, pyelitis, etc.

A short survey of the principal features of the disease at its early period will establish the basis of the problem. The age of the patients varies between 20 and 35, most of them, after careful questioning, relating the onset of the first mild symptoms to have occurred between the ages of 18 and 25 years. Male patients are observed almost exclusively, the disease among women being a rarity.

In 60 per cent of the cases, a history of past genito-urinary ailment is reported, not always gonococcal, sometimes due to *Bacillus coli* or any other infectious germ. It is quite suggestive that these patients are relieved of their lumbar pains by the reclining position in the first part of the night, but are frequently obliged to get up several times in the second part of the night

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[1] This is one of a series of papers contributed by friends and former pupils of I. Seth Hirsch, M.D.

[2] The abbreviation "A. S." will be used for "ankylosing spondylarthritis" in the course of this paper.

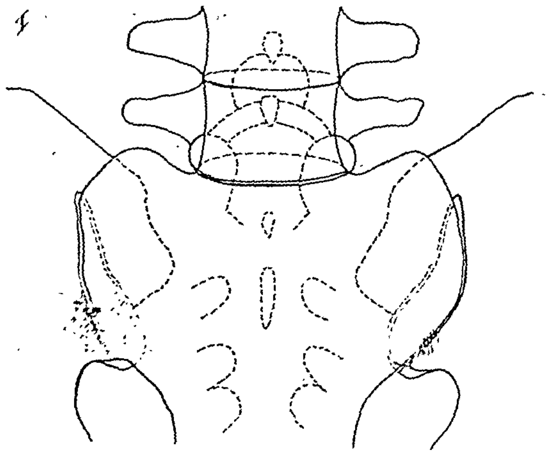

Fig. 1. Sacro-iliac changes in ankylosing spondylarthritis. First stage, marginal decalcification.

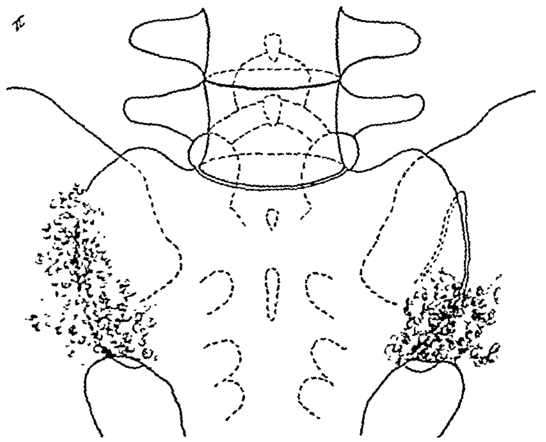

Fig. 2. Second stage, picnotic formation. A large area of bone, both on the sacrum and on the ilium, shows a mottled appearance with decalcification and hypercalcification.

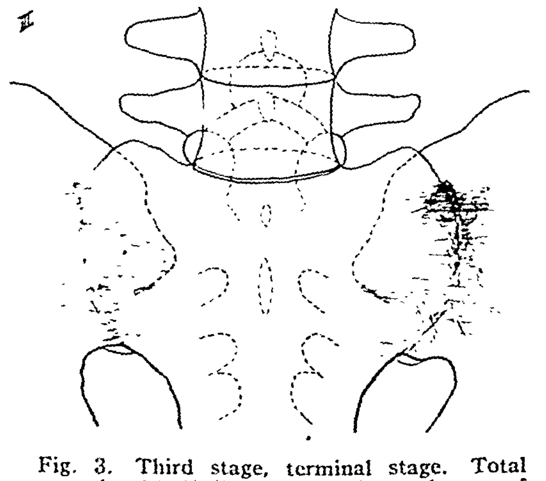

Fig. 3. Third stage, terminal stage. Total synostosis with fibrillary ossification and areas of osteosclerosis.

to relieve the muscular spasm in their spinal muscles. The value of blood tests to prove that an inflammatory condition is present is almost as important as in rheumatoid arthritis. Over 80 per cent of these patients show an accelerated sedimentation rate, which we check in France by the resorcine flocculation test (Vernes), which gives almost constantly high figures in the active part of the evolution of ankylosing spondylarthritis.

For many years, the roentgenographic examination has not been very helpful in the early diagnosis of A. S., since clinical observation has proven that a long period of time could elapse before some degree of ossification (bridging) appears between the vertebræ. Not only are these changes not visible roentgenologically in the inflammatory period of the disease, but fibrous ankylosing may have taken place and stiffened a part of the spine without any apparent changes other than a mild diffuse general osteoporosis of the bony structures of the pelvis and the spine. The intervertebral discs are generally normal in height and the contours of the vertebræ are normal both of the bodies and of the various processes.

Some authors have claimed that early changes could be detected on x-ray films with a proper technic (oblique views) in the joint spaces of the articulations—thinning of the joint spaces, decalcification of the articular processes. However, experience shows that the interpretation of these changes is often subject to criticism. It has been reported that the facet joints may appear normal even when ossifications had already appeared between the bodies of the vertebræ.

We have found, during recent years, that in opposition to these doubtful vertebral signs that *the roentgenographic changes in the sacro-iliac joints are of enormous value in the early diagnosis of A. S.* It is our aim to prove that the association of some clinical signs in the spine and especially in the lumbar region (pain, stiffness, lumbosciatica, etc.), with some definite roentgenographic signs in the sacro-iliac joints,

are pathognomonic of A. S. To demonstrate the correctness of our views, we shall discuss the following points:

(*A*) Are sacro-iliac joints always involved in the course of A. S.?

(*B*) Are sacro-iliac joints involved *previous* to the vertebral changes?

(*C*) What are the typical roentgenographic changes which sacro-iliac joints undergo at the beginning of A. S.?

II

Sacro-iliac Joints in the Course of Ankylosing Spondylarthritis.—Though Pierre Marie and Léri had reported in their first description of the pathologic changes of the disease that the sacro-iliac joints had undergone a bony ankylosis, it is only in the last decade that the roentgenologists have noticed that this fusion appeared to be associated with the well-known appearance of bamboo-spine. In a review of the modern literature of A. S., we have found this fact mentioned by Krebs and Vontz (2), Swaim and Kuhns (3), and others. In 1936, G. Scott (4), reporting 110 cases of what he called "spondylitis adolescens," found in all cases without exception either a synostosis of these joints or some abnormalities in their roentgenographic appearance. C. W. Buckley, in 1935 (5), in a wide survey of more than a hundred cases, stated that in the majority he had found a complete bony ankylosis of the sacro-iliac joints: in one case only these joints appeared to be normal. In nine cases, some gross changes had taken place but the joints were not fused. Both Scott and Buckley reported a few cases in which these sacro-iliac changes had been detected at an early period of the evolution of the disease and previous to any changes in the roentgenologic aspect of the joints of the facets. Personally reviewing 153 cases of A. S. which came under our observation at any period of their disease, we found only two cases in which the sacro-iliac joints did not appear to be roentgenologically involved. The first case was that of a middle-aged man complaining of pains in his knees, without any vertebral symptoms, but we found some stiffness in his neck and the roentgenogram revealed two ossifications (bridging) uniting some cervical vertebræ. The sacro-iliac joints and the lumbar vertebræ were normal; the sedimentation rate was also normal. We are not certain that this case was a true A. S.

The second case is a man, 60 years of age, affected with diabetes for about ten years, who started, about the same time, to complain of lumbago and pains radiating from the pelvic girdle. When we examined him, his spine was incompletely ankylosed in its three segments and both hips were very much impaired in their movements. The sedimentation rate was 26 for the first hour (Westergren) and the resorcine flocculation test was also abnormal. The roentgenographic examination of his pelvis and spine revealed rather advanced changes of atrophic arthritis in both hips but both sacro-iliac joints were practically normal. No change could be detected in the lumbar spine. We believe that this is really the first case of A. S. in which the sacro-iliac joints were roentgenographically normal; but we must point out that the spine itself was free from the typical changes of the disease.

III

Sacro-iliac Joints are Involved Earlier than the Spine.—To prove this point, we have extracted from the bulk of our clinical material, which amounts to 153 cases of A. S., 12 cases in which patients showing the clinical picture of this disease revealed some definite roentgenographic changes in their sacro-iliac joints *though the spine was free from any abnormality.* Let us sum up rapidly the principal features of these cases.

Age.—All our patients, but two, were observed around the age of 30 years and most of them had complained of functional symptoms in the spine since the age of from two to eight years. These findings confirm the view expressed by G. Scott that the disease belongs to adolescence in most cases.

Sex.—All our patients were males, which is an additional confirmation of the enormous preponderance of the disease among men.

mild tuberculosis of the lungs was noted; in five cases, no definite infection could be established in the past history.

Duration.—In most cases, the duration

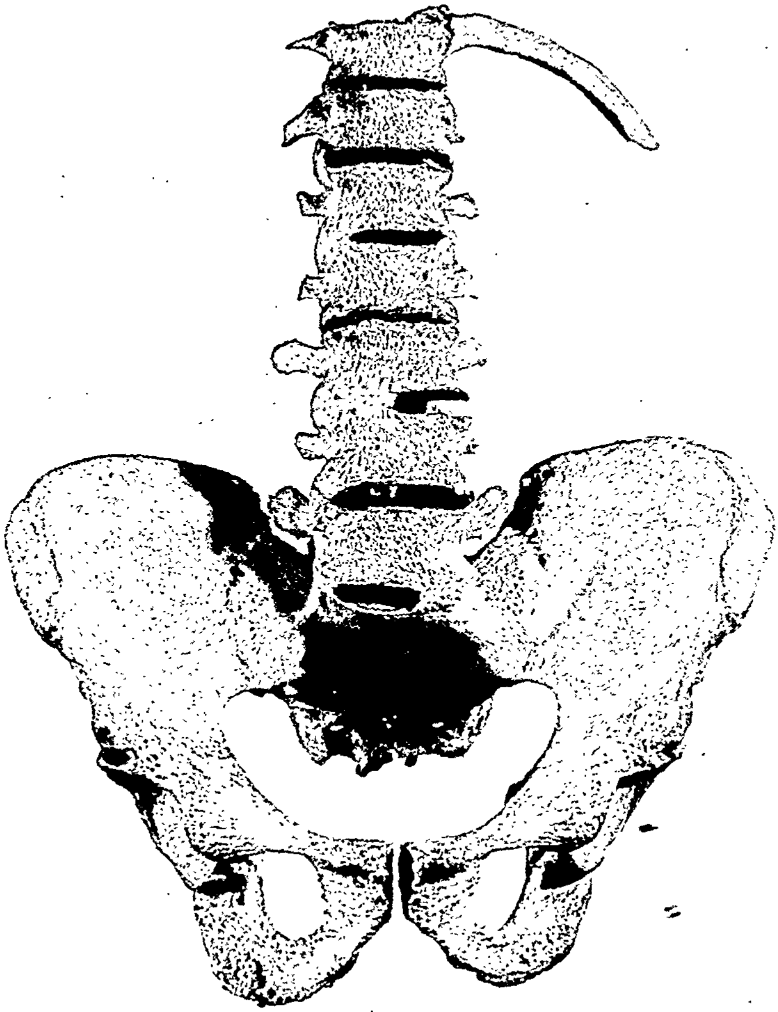

Fig. 4. Dried specimen of a relatively early case of ankylosing spondylarthritis. The "syndesmophytes" (bridging) have not yet invaded the entire intervertebral spaces. Note bilateral sacro-iliac fusion.
(*Courtesy of Gazette Médicale de France.*)

Past History.—In spite of the fact that the existence of any focus of infection does not entail the certainty of its being the cause of any chronic disease occurring later on, we must point out that one-third of our patients had had some gonococcal infection, some time previously. In one case,

was less than four years, but it is sometimes very difficult to make an accurate statement, since the early symptoms are slight and the progression of the disease very slow. It is impossible to state, even with some approximation, how long after the onset of the disease the first ossifica-

tions appear in the spine. In a young priest, aged 32 years, pains had appeared in the joints since the age of 12 years, with lumbar pains the past six years. It is remarkable that, as a rule, no pain was elicited by pressure at the site of the sacro-iliac joints.

Blood Changes.—In all cases without

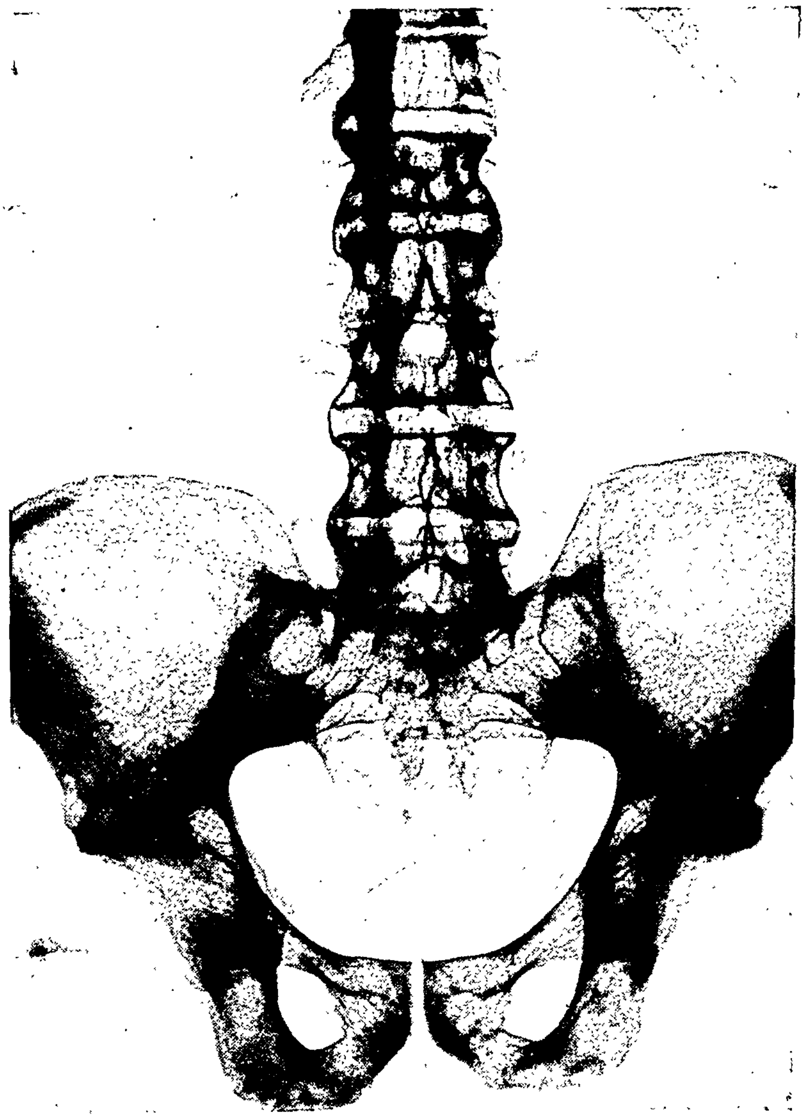

Fig. 5. Roentgenogram of same specimen taken in the same position as the photograph of Figure 4.

(*Courtesy of Gazette Médicale de France.*)

The spine was roentgenologically normal, though both sacro-iliacs were involved.

Clinical Picture.—In all our cases, the patients complained of pains and stiffness in the spine with muscular contracture and impairment in the chest expansion. By examination, tender areas were found along the spinous processes and on pressure at the site of some apophyseal (facets) joints.

exception the sedimentation rate and the resorcine flocculation test were grossly abnormal and proved that an inflammatory condition was in process.

IV

Roentgenographic Changes in the Sacro-iliac Joints in the Early Stages of Ankylosing Spondylarthritis.—The roentgeno-

graphic study of the sacro-iliac joints has been the subject of many papers during the past years. In almost every country, roentgenologists of experience have tried to find the technic best for the proper visualization of these joints. We shall not go into the details of the various technics since they are not of great value in the study of the early changes of the sacro-iliac joints in A. S. The reason is that most of these changes do not especially affect the joint space, but much more the adjacent bony structures of the sacrum and the ilium. These changes, as experience has shown us, are much more accurately detected on a routine frontal view of the pelvis (the sacrum lying against the film, the lumbar lordosis being reduced by bending the knees, the thighs in abduction). This technic shows the sacro-iliac joints' surfaces in their longest development as shown by Bărsony and Schülhoff (6). It affords a good comparison between both sides and, curiously enough, reveals more details in the structure of the bones adjoining the sacro-iliac joints than the special oblique views designed to map out the joint space of one sacro-iliac. This is true presumably because the abnormal area is projected on the film on a wider surface than when the roentgen rays strike the joint space tangentially.

Roentgenographic Changes.—These deal with the joint space, the contours of the bones, and the structure of the subchondral bone, these last two elements being of much greater importance than the first one. Indeed, the joint space is not, as a rule, thinned and does not become irregular by cartilage or bone erosion as in a true arthritis. We admit the difficulty of interpreting these early cases, since we know the great variability of the roentgenographic films of the sacro-iliac joints in normal persons. We want to emphasize that in some cases the changes which we describe do not, at the beginning, affect the entire length of the joint but only a part of it. The rest of the joint space appears to be absolutely normal. Later on, the entire joint becomes abnormal and the joint space disappears altogether very rapidly without passing through a stage of diminution of its width. To make our description more clear, we have classified our cases in three stages.

First Stage: Pseudo-widening of the Joint Space.—On a segment of one or both joints, generally in the lower segment, the contours of the subchondral bone become woolly and hazy; the clear-cut outline of the joint space on the iliac side disappears entirely. There is a loss of calcium alongside the margin of the bone. This *marginal decalcification* results in the appearance of a widening of the joint space (Fig. 1).

Second Stage: Picnotic Formation in the Joint Area.—The development of the first stage ends, after several months or a year, in a mottled appearance of the cancellous bone both on a wide area of the lateral portion of the sacrum and of the ilium. Some small spots appear very translucent, some look hypercalcified (in French: *aspect tigré*) (Fig. 2), or spotted.

Third Stage: Loss of Joint Space and Synostosis.—This is a far remote stage and a terminal one. In the previous stage the joint space is hardly visible on the mottled surface. At this stage, there is more uniformity in the calcification of the sacro-iliac region. Some thin ossified fibers appear transversely across the joint space and this fibrillary structure is often accompanied by osteosclerosis in the adjoining regions. In the course of the disease the bony densification tends to become more and more marked. This stage was rarely observed in our cases since it is generally a contemporary of the existence of the ossifications between the vertebræ. In the greatest majority of cases, such changes affect the whole length of both sacro-iliac joint spaces and are frequently accompanied by ossification of the iliolumbar ligaments.

Considering the changes in our 12 early cases, we find that in nine both sacro-iliacs were involved, but generally each of them partially. In the other three instances, the changes were unilateral and also partial.

V

Differential Diagnosis.—The association of clinical signs of lumbar pains and stiffness with roentgenographic changes in the sacro-iliacs, which do not give rise to any clinical symptoms, can hardly be mistaken for another pathologic condition.

What is commonly called *sacro-iliac arthritis* (*hypertrophic*), a clinical condition consisting of lumbar and pelvic pains appearing in elderly and stout women with weak muscles and ligaments, is a very peculiar syndrome which has hardly any point of conjunction with the subject we are considering. We almost never observe it in men, while these are affected with A. S. much more frequently than women. On examination of these patients, there is no real lumbar stiffness but only some muscular spasm, and the sacro-iliac joints are very tender under finger pressure; a sign which almost never occurs in A. S. The clinical symptoms, which are sometimes very violent, are in

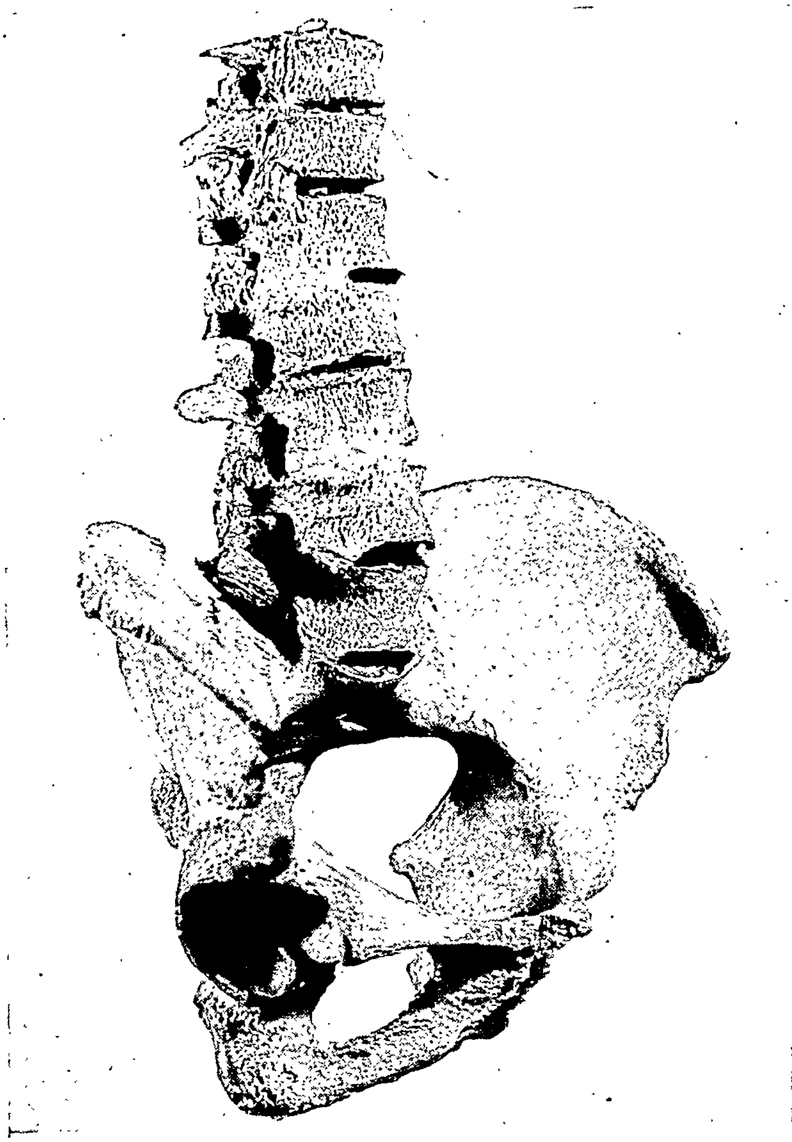

Fig. 6. Same specimen as that shown in Figure 4. Right anterior oblique view. The vertebral ossifications are clearly seen frontally.
(*Courtesy of Gazette Médicale de France.*)

direct contrast with the absence of roentgenographic changes in the sacro-iliacs. Furthermore, we do not believe that this condition is a true arthritis but merely a joint insufficiency due to the fact that the static forces are by exception in only this joint of the body parallel to the joint space. It is easy to understand that any weakness in the sacro-iliac ligaments and the adjoining muscles will bring about a painful distention causing suffering.

Sacro-iliac tuberculous arthritis may occur in adults—in females as well as in males—and can be the cause of pains in the sacro-iliac region and of diverse nervous radiations in the lower limbs and the pelvis. A confusing point with A. S. is that this condition may be associated with an impairment of the general condition, low-grade temperature, and an accelerated sedimentation rate. In the early stages the roentgenographic findings are nega-

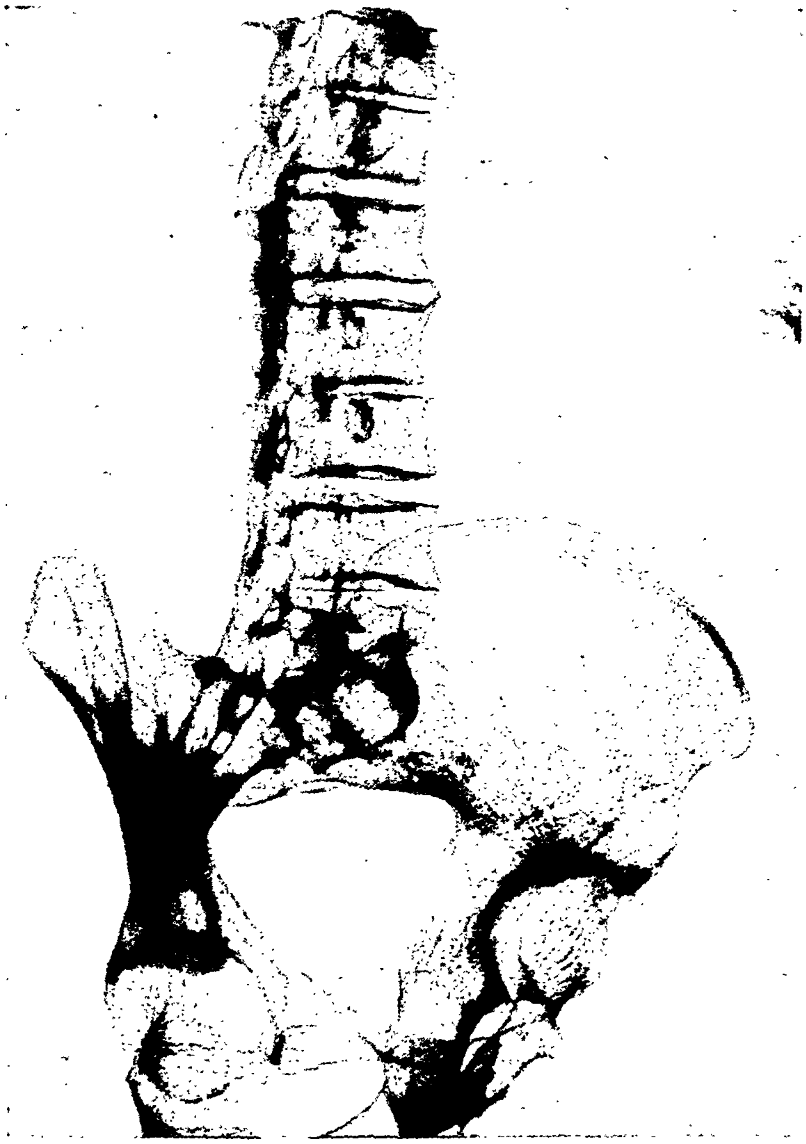

Fig. 7. Roentgenogram of same specimen taken in same position as the photograph of Figure 6. As the rays pass through the ossifications normally, the latter can scarcely be seen.

(Courtesy of Gazette Médicale de France.)

tive, but, later on, when they appear they consist of definite bone destruction in a limited area, an entirely different picture from any of the ones which we have described in A. S.

A question may arise as to whether or not there exists a congenital obliteration of one or both sacro-iliac joints. We have never observed it. It might be the result of a fetal infection and would be proved certainly much earlier in life than the time of onset of A. S.

Infectious sacro-iliac arthritis deserves a much more accurate consideration since this condition is very close to the one which we observe at the onset of A. S. The roentgenographic changes consist of a rather diffused area of decalcification, the joint space becoming less and less visible. But in the very few cases which have come under our observation, we have been struck by the constant association of clinical symptoms in the lumbar region associated with these findings, and at least two cases which were primarily labelled "sacro-iliac arthritis" a few years ago have proved, in the course of time, to be definite cases of A. S. In two additional cases the diagnosis of sacro-iliac arthritis had been laid down from four to six years previously by qualified physicians, and when they came under our observation they had developed unquestionable symptoms of A. S. It is well to mention that 12 cases reported as bilateral sacro-iliac obliteration by S. C. Woldenberg (7), 14 years ago, were certainly, for their greatest majority, early cases of A. S., since the clinical description of the cases with the preponderance of vertebral symptoms is absolutely typical of the disease. Roentgenographic changes of these cases described by Blaine, in 1923, are very similar to ours but no interpretation was given.

In 16 cases of A. S. detected by us, we were able to prove by re-interpreting the roentgenograms taken two, four, or even eight years previously, that sacro-iliac changes were already existent at that early stage but had been overlooked by qualified roentgenologists. Gilbert Scott has started a methodical survey in which he intends to radiograph all sacro-iliac joints of young men between the ages of 20 and 30 years who come to the Red Cross Clinic in London. It will be most interesting within a few years to find out, from among those who showed sacro-iliac changes of the type described by us, what percentage has developed A. S. We feel relatively sure that this percentage will be very high.

But we must remark that this disease has not such a chronic tendency as rheumatoid arthritis and may sometimes stop in its course even though untreated. We have seen a case in which, on the occasion of a roentgenographic examination, one sacro-iliac joint was obliterated and two ossifications were detectable between the third, fourth, and fifth lumbar vertebræ. Ten years previously, this man, about 25 years of age, had undergone a period of chronic lumbago for two years. Without any treatment the disease had been arrested before giving rise to its essential clinical symptoms on the spine.

VI.—DISCUSSION

After reviewing 153 cases of A. S., some of which we have followed during many years, we have been struck by the following features of the disease:

(*A*) It occurs very rarely in women.

(*B*) Patients frequently give a previous history of genital infection: prostate, seminal vesicles, or rectosigmoidal disturbances.

(*C*) The disease has a very low-grade evolution, the onset often being difficult to determine. It progresses upward from the pelvis to the cervical region, and to the joints of the roots of the limbs.

(*D*) The roentgenographic changes in the sacro-iliacs are contemporary of the early and confused low back symptoms and precede, in most cases, the vertebral involvement.

From these deductions, we have tried, since four years ago (8), to present a pathogenesis of the disease which would explain completely its special features.

We believe that the primary focus in A. S. is in the genito-urinary system or in the low part of the bowels, and that the toxic products excreted by this focus are drained into the lymphatic system of the pelvis and from this place alongside the spine. In the male, the lymphatic vessels from the prostate and the seminal vesicles pass, on both sides of the medial line, in front of each sacro-iliac joint, and extend upward in the posterior part of the abdomen on both sides of the spinal column just in front of the apophyseal joints with which they have many connections. They are directly applied on the vertebral column behind the aorta and the vena cava.

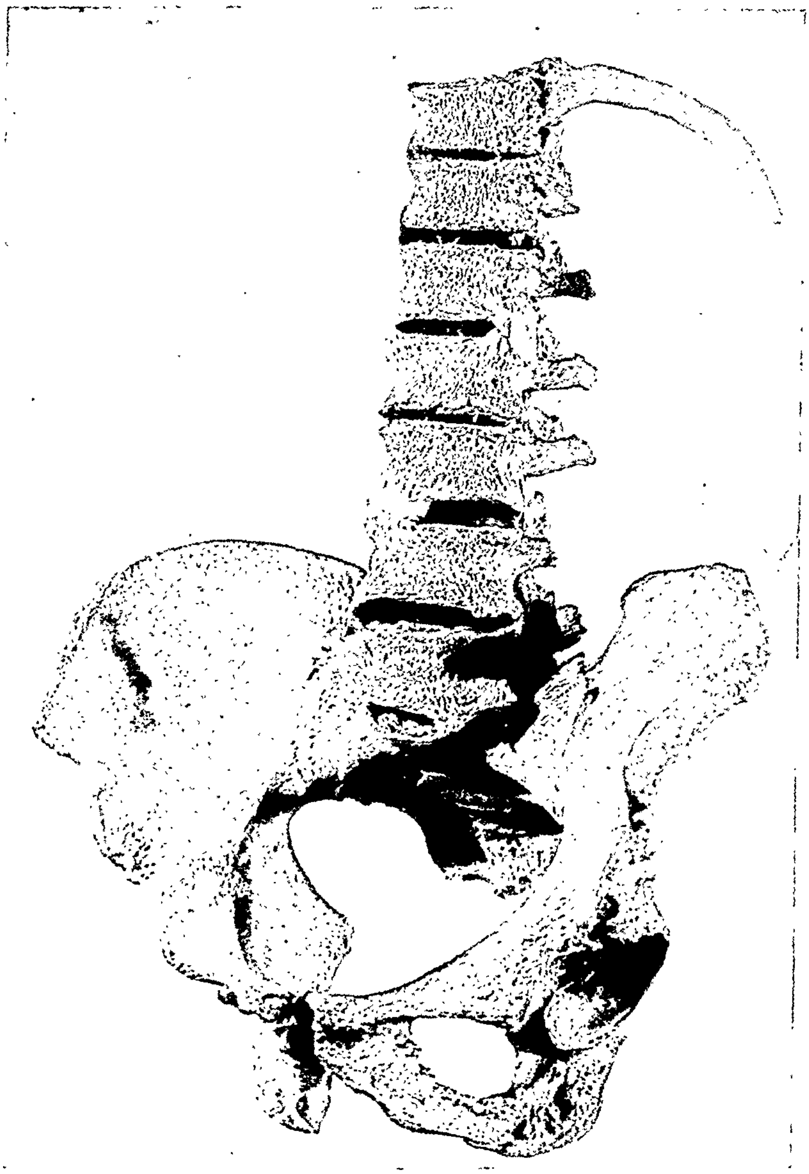

Fig. 8. Same specimen as that shown in Figure 4. Left anterior oblique view. The vertebral ossifications can hardly be seen.
(*Courtesy of Gazette Médicale de France.*)

In the female, the lymphatic vessels of the uterus and the vagina follow approximately the same path and also lie near the intervertebral joints. Conversely, the lymphatic vessels of the Fallopian tubes and of the ovaries are much more laterally

situated in the pelvis, and when they come up into the abdomen they lie on the ventral aspect of the large blood vessels—aorta and vena cava. They have very few anastomotic connections with the rest of the retro-aortic system (Rouvières). Since we know that the draining of the uterus and vagina is far easier than that of the ovaries and tubes, we can understand why the occurrence of A. S. is so infrequent among females. This theory explains quite satisfactorily the slow progression of the disease; first to the sacro-iliac joints and later ascending along the different segments of the spine.

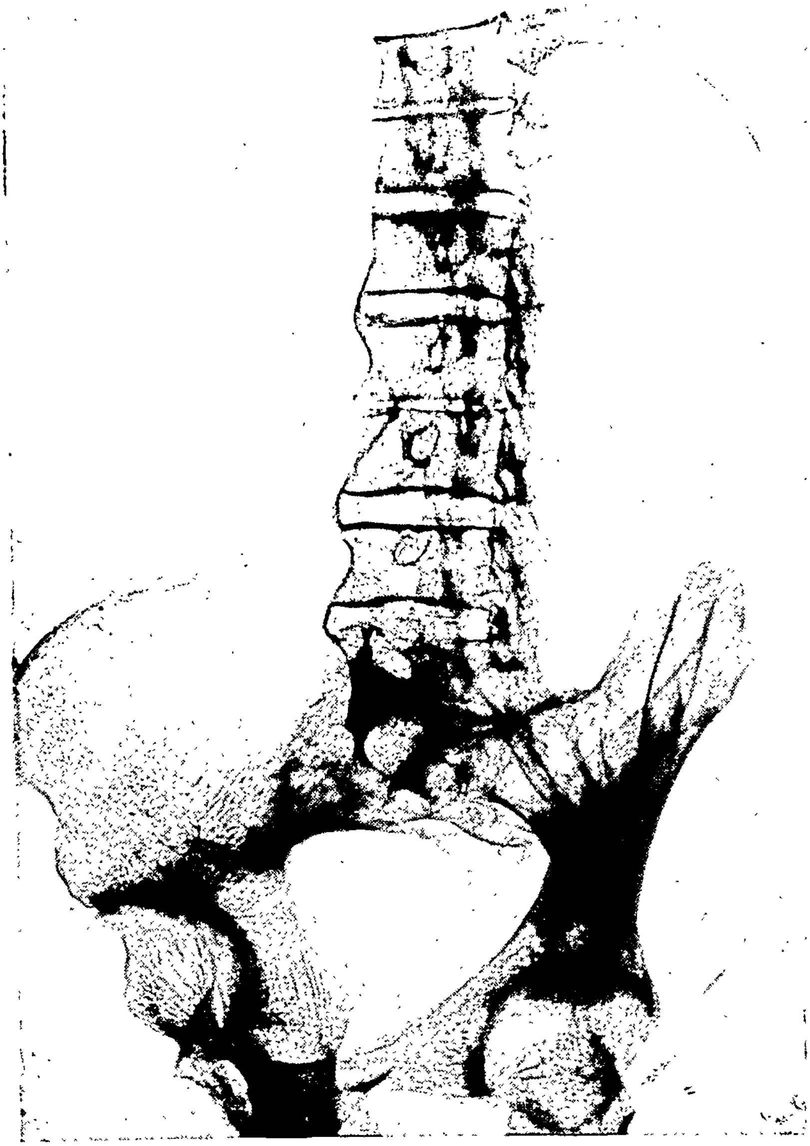

Fig. 9. Roentgenogram of same specimen taken in same position as in Figure 8. As the roentgen rays fall upon the ossifications tangentially, the latter are best seen. Compare with Figure 7.
(*Courtesy of Gazette Médicale de France.*)

VII.—BRIEF COMMENTS ON INTERVERTEBRAL OSSIFICATIONS

Every physician is aware of the typical bamboo-spine which is the roentgenographic feature of A. S. in its terminal

stage. But there are still many mistakes made in the earlier stages when only a few ossifications have appeared. Most of them are described as osteophytes and no special attention is given them. Thus, the serious condition of a total ankylosis of the spine which may appear later is thoroughly overlooked. We have given the name of "syndesmophytes" (9) to those ossifications which, from the very beginning of their onset, have a tendency to unite two adjacent vertebræ (bridging). Syndesmophytes can be easily distinguished from the osteophytes from the beginning since the former appear as a woolly shadow in the intervertebral space which, within a few months, is transformed into a rather clear-cut, dense, linear calcification without a cortex having the appearance of a thin or a thick comma, added to the contour of the vertebral body. The osteophytes on the contrary have a much thicker base, are covered with a cortex which comes from that of the vertebral body, and a structure of cancellous bone like the vertebral body itself.[3] Since the opportunity has been rarely given of checking the roentgenographic findings with the pathologic specimens of A. S., the difference in these structures in their early stages could not be proved. We had the good fortune of viewing a spondylarthritic spine of rare specimen in which the ossifications had not yet completely invaded all the intervertebral spaces (10). The photographs and the roentgenograms of this specimen at various angles are reproduced herein (Figs. 4 to 9). It will be easy, from this comparative study to understand why our diagnostic findings in A. S. are relatively limited. Most of the thin layers of dense bone uniting the vertebræ at the periphery are not shown in the roentgenograms when these are in the normal path of the roentgen ray. It is only when a tangential ray strikes one of these pathologic structures that its opacity is sufficient to appear on the film, and one little opaque comma generally indicates a very wide ossified structure. These figures show also that for the certain detection of these vertebral ossifications at an early stage, several films must be taken at different angles—frontal, lateral, oblique.

[3] This term means a growth from the ligament, in opposition to "osteophyte" which means a growth from the bone.

VIII.—THERAPEUTIC DEDUCTIONS

The preceding considerations as to the early diagnosis of A. S. are not merely academic. Every chronic disease must be treated at the beginning and not at the end, and experience has proved that A. S., when actively treated in its pre-ankylosing period, is a curable condition.

Among the treatment methods proposed for this disease, we must recall briefly the usual measures, especially physiotherapy, which, for many physicians, is the basis of treatment. The most important measure is functional rest which is obtained by prolonged decubitus; it may be improved by the use of a plaster shell supporting the whole spine, a method applied by the Boston Orthopedic School and emphasized by Loring Swaim (3). Among the other therapeutic measures, the use of heat to the spine by electric lamps, short waves, or diathermy certainly has an analgesic value. At Aix-les-Bains, in the active periods, we use reclining baths or deep baths associated with undercurrent spray (*douche sous-marine*). When the disease has partially subsided, hot showers (*bouillon*) associated with gentle douche-massage are of definite value to improve the mobility of the spine and counteract muscular atrophy.

But in our experience, two internal treatments have proved of very great value, not only as symptomatic measures, but for the treatments of the disease itself. They are gold salts injections (chrysotherapy) and radio-active injections (thorium X or radon).

Chrysotherapy.—Since we introduced gold salts in the treatment of rheumatoid arthritis more than ten years ago, this method has spread in almost every country and is being used to date in the United States. A. S., though a different disease from rheumatoid, belongs to the group of

atrophic and inflammatory arthritis and thus is amenable to gold salts treatment. We use it especially in active stages of the disease when the clinical symptoms of pain and stiffness are associated with a high sedimentation rate. I described the technic of these injections four years ago in the *Journal of Laboratory and Clinical Medicine* (11). Intravenous injections are not necessary and we generally use intramuscular injections of myochrysine, allochrysine, myoral, or solganal B. Since the action of these different compounds is very similar, moderate doses not exceeding 10 cg. per week and 1 gr. 20 for one series, are sufficient. But the series must be repeated at two- or three-month intervals as long as the disease remains active.

Radio-active Injection.—The use of radioactive preparations injected intramuscularly or intravenously was introduced in the treatment of A. S. by means of thorium by A. Léri, 14 years ago. These injections are given at weekly intervals with a rising dosage from 50 to 150 or 250 micrograms. A series consisting of eight or ten injections and totalling between 800 and 1,200 micrograms are given. As thorium X does not seem to be available in many countries, we have in the past three years used gaseous injections of radon. The latter is produced by small metallic tubes containing a definite amount of radium element. When the proper amount of radon has accumulated in the closed tube, it is connected on one side with a hypodermic needle, and on the other side with a 20 c.c. syringe of oxygen or even sterilized air. By pushing the latter through the tube the radon is expelled, injected under the skin, and promptly absorbed by the general circulation. We have used a dosage of from 6,000 to 12,000 millimicrocuries, given every second day, with a total of from 12 to 20 injections for one series. The series may be repeated after an interval of from four to six months. We have observed no untoward effect.

The use of radon is reserved to the less active stages of the disease and also to cases of longer standing.

The results of the internal treatment of A. S. in its early stages by the use of gold salts or radon or by alternate series of each have been most satisfactory. After a few weeks or a month or two, the vertebral pains subside progressively and the motion of the spine increases. This is not a purely symptomatic action; if the treatment is pursued for one or two years, by repeated series, the arrest of the disease may be total. Among 25 cases treated by this method in the pre-ankylosing period which have remained under observation during two to five years, 80 per cent have been made thoroughly free of symptoms after one or two years' treatment. Only 15 per cent have experienced some relapse, which could be checked by resuming treatment. In only a few cases, some vertebral ossifications (syndesmophytes) have appeared after the beginning of the treatment. Most of the patients have retained a certain amount of vertebral stiffness but the absence of any pain has permitted an almost complete functional activity.

We feel that if every case of A. S. were treated in its early stage along these lines, with patience and perseverance, the picture of *spondylose rhizomélique*, with a total ankylosis of the whole spine and the sacroiliac hip and shoulder joints would become an extreme rarity.

SUMMARY

1. From the examination of 153 cases of ankylosing spondylarthritis, it appears that sacro-iliac joints are roentgenographically involved in over 98 per cent of the cases.
2. From the examination of 12 cases observed in the very early stages of the disease, evidence is given that sacro-iliac joints are roentgenographically involved previously to any changes of the spine. The reverse has not been observed.
3. A description of the roentgenographic changes in the sacro-iliac joints is given.
4. An hypothesis is presented which explains the causes, the onset, and the progress of ankylosing spondylarthritis.

position that the hospitals pay the roentgenologist stipulated salaries; hence, no individual payments are made." The information this correspondent has received is obviously inaccurate, in view of the fact that a number of States do provide for the payment of fees for radiological services under plans that are approved by the Children's Bureau. The decision reached in these States is, therefore, a local and arbitrary one and has not been influenced by the federal authorities charged with the approval and advisory control of state plans.

In Alabama, California, Colorado, Connecticut, Indiana, Kentucky, Michigan, Minnesota, Montana, Nebraska, Oregon, Texas, Utah, Vermont, and Wisconsin, correspondents reported that the state administrative agency provides for payment for radiological services performed on crippled children. In most of these, payments are made according to an adopted fee schedule. As stated above, these fee schedules are customarily on a reduced basis and the maximum amount allowed for any single examination is usually around ten dollars. In a few States, it is no higher than five dollars per examination. In some States, a complete schedule has been approved, setting forth the fee allowed for various procedures. In a few States, the fee schedule is used only for out-patients or for after care and check-ups. Radiological services in these plans are included in the *per diem* payment allowed to hospitals while the beneficiary is confined to the hospital.

Included in the regulations of nearly every state plan is the provision that specialists performing services for the beneficiaries of the act must be certified by their national examining board and in such cases radiologists are not permitted to receive remuneration for their services unless they are diplomates of the American Board of Radiology.

In North Carolina, it is reported that no arrangement is made for payment to radiologists while anesthetists are remunerated for services rendered on a fee-schedule basis. The same is no doubt true in some other plans in which no provision is made for radiological fees.

To those radiologists in States where no provision is made for fees for radiological services, the Inter-Society Committee suggests that conferences be held with the local authorities in an effort to secure a more equitable arrangement. All these projects are admittedly of a charitable nature and fees should be reduced to a minimum, but there is no good reason why recognition should not be given to the important rôle of roentgen diagnosis as a necessary preliminary to the institution of orthopedic measures. For services rendered to both in-patients and out-patients, arrangements should be made for paying for radiological diagnosis on a reduced fee schedule. Even in those institutions where radiological fees for services rendered to hospitalized patients is customarily collected by the hospital, it is unfair to both the hospital and the radiologist to expect these services to be rendered as a part of hospital care and included in the *per diem* allotment in the case of beneficiaries of the crippled children's program.

MAC F. CAHAL,
Executive Secretary

RADIOLOGICAL SOCIETIES IN THE UNITED STATES

Editor's Note.—Will secretaries of societies please cooperate with the Editor by supplying him with information for this section? Please send such information to Leon J. Menville, M.D., 1201 Maison Blanche Bldg., New Orleans, La.

CALIFORNIA

California Medical Association, Section on Radiology.—Chairman, Karl M. Bonoff, M.D., 1930 Wilshire Blvd., Los Angeles; *Secretary,* Carl D. Benninghoven, M.D., 95 S. El Camino Real, San Mateo.

Los Angeles County Medical Association, Radiological Section.—President, E. N. Liljedahl, M.D., 1322 North Vermont Ave., Los Angeles; *Vice-president,* M. L. Pindell, M.D., 678 South Ferris Ave.; *Secretary,* Wilbur Bailey, M.D., 2007 Wilshire Blvd.; *Treasurer,* Henry Snure, M.D., 1414 South Hope Street. Meets every second Wednesday of each month at County Society Building.

Pacific Roentgen Club.—Chairman, Karl M. Bonoff, M.D., Los Angeles; *Members of Executive Committee,* I. S. Ingber, M.D., A. C. Siefert, M.D., D. R. MacColl, M.D.; *Secretary-Treasurer,* L. Henry Garland, M.D., 450 Sutter St., San Francisco. Executive Committee meets quarterly; Club meets annually during annual session of the California Medical Association.

San Francisco Radiological Society.—Secretary, L. H. Garland, M.D., 450 Sutter Street. Meets monthly on first Monday at 7:45 P.M., alternately at Toland Hall and Lane Hall.

COLORADO

Denver Radiological Club.—President, F. B. Stephenson, M.D., 452 Metropolitan Bldg.; *Vice-president,* K. D. A. Allen, M.D., 452 Metropolitan Bldg.; *Secretary,* E. A. Schmidt, M.D., 4200 E. Ninth Ave.; *Treasurer,* H. P. Brandenburg, M.D., 155 Metropolitan Bldg. Meets third Tuesday of each month at homes of members.

CONNECTICUT

Connecticut State Medical Society, Section on Radiology.—Chairman, Samuel M. Atkins, M.D., 63 Central Ave., Waterbury; *Secretary-Treasurer,* Max Climan, M.D., 242 Trumbull St., Hartford. Meetings twice annually in May and September.

DELAWARE

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Florida Radiological Society.—President, H. B. McEuen, M.D., Jacksonville; *Vice-president,* Joseph H. Lucinian, M.D., Miami; *Secretary-Treasurer,* John N. Moore, M.D., 210 Professional Bldg., Ocala. Meetings held in November and at the annual meeting of the Medical Association of Florida in the spring.

GEORGIA

Georgia Radiological Society.—President, James J. Clark, M.D., Doctors Bldg., Atlanta; *Vice-president,* L. P. Holmes, M.D., University Hospital, Augusta; *Secretary-Treasurer,* Robert C. Pendergrass, M.D., Prather Clinic, Americus. Meetings twice annually, in November and at the annual meeting of the Medical Association of Georgia in the spring.

ILLINOIS

Chicago Roentgen Society.—President, Roe J. Maier, M.D.; *Vice-president,* Adolph Hartung, M.D.; *Secretary,* Chester J. Challenger, M.D., 3117 Logan Blvd. Meetings the second Thursday of each month from October to May, except December, at the Hotel Sherman.

Illinois Radiological Society.—President, Cesare Gianturco, M.D., 602 W. University Ave., Urbana; *Vice-president,* Fred H. Decker, M.D., 802 Peoria Life Bldg., Peoria; *Secretary-Treasurer,* Edmund P. Halley, M.D., 968 Citizens Bldg., Decatur. Meetings quarterly by announcement.

Illinois State Medical Society, Section on Radiology.—The next meeting will be in Peoria, in May, 1940. The officers are: *Chairman,* Warren W. Furey, M.D., 6844 Oglesby Ave., Chicago; *Secretary,* Harry W. Ackemann, M.D., 321 W. State St., Rockford.

INDIANA

The Indiana Roentgen Society.—President, Juan Rodriguez, M.D., 2902 Fairfield Ave., Fort Wayne; *President-elect,* H. H. Inlow, M.D., Shelbyville; *Vice-president,* Wemple Dodds, M.D., Crawfordsville; *Secretary-Treasurer,* Clifford C. Taylor, M.D., 23 E. Ohio St., Indianapolis. Annual meeting in May.

IOWA

The Iowa X-ray Club.—Holds luncheon and business meeting during annual session of Iowa State Medical Society.

KENTUCKY

Kentucky Radiological Society.—President, D. B. Harding, M.D., Lexington; *Vice-president,* I. T. Fugate, M.D., Louisville; *Secretary-Treasurer,* Joseph C. Bell, M.D., 402 Heyburn Bldg., Louisville. Meeting annually in Louisville, third Sunday afternoon in April.

MAINE

See New England Roentgen Ray Society.

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MASSACHUSETTS

See New England Roentgen Ray Society.

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Vice-president, Clarence Hufford, M.D., 421 Michigan Ave., Toledo, Ohio; *Secretary-Treasurer*, E. R. Witwer, M.D., Harper Hospital, Detroit. Meetings first Thursday of each month from October to May, inclusive, at Wayne County Medical Society club rooms, 4421 Woodward Ave.

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MISSOURI

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The St. Louis Society of Radiologists.—President, Paul C. Schnoebelen, M.D.; *Secretary*, W. K. Mueller, M.D., University Club Bldg. Meets on fourth Wednesday of October, January, March, and May, at a place designated by the president.

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Nebraska Radiological Society.—President, T. T. Harris, M.D., Clarkson Memorial Hospital, Omaha; *Secretary*, D. Arnold Dowell, M.D., 117 S. 17th St., Omaha. Meetings first Wednesday of each month at 6 P.M. in Omaha or Lincoln.

NEW ENGLAND ROENTGEN RAY SOCIETY

(Maine, New Hampshire, Vermont, Massachusetts, and Rhode Island.) *President*, Langdon T. Thaxter, M.D., Maine General Hospital, Portland, Maine; *Secretary*, Aubrey O. Hampton, M.D., Massachusetts General Hospital, Boston. Meetings third Friday of each month from October to May, inclusive, usually at Boston Medical Library.

NEW HAMPSHIRE

See New England Roentgen Ray Society.

NEW JERSEY

Radiological Society of New Jersey.—President, P. S. Avery, M.D., Middlesex Hospital, New Brunswick; *Vice-president*, J. G. Boyes, M.D., 912 Prospect Ave., Plainfield; *Treasurer*, H. A. Vogel, M.D., 1060 E. Jersey St., Elizabeth; *Secretary*, W. James Marquis, M.D., 198 Clinton Ave., Newark; *Counsellor*, A. W. Pigott, M.D., Skillman. Meetings at Atlantic City at time of State Medical Society, and Midwinter in Newark as called by president

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Brooklyn Roentgen Ray Society.—President, A. L. L. Bell, M.D., Long Island College Hospital, Henry, Pacific, and Amity Sts.; *Secretary-Treasurer*, L. J. Taormina, M.D., 1093 Gates Ave. Meetings first Tuesday in each month at place designated by president.

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Line St., Rocky Mount; *Secretary-Treasurer*, Major I. Fleming, M.D., 404 Falls Road, Rocky Mount. Meetings with State meeting in May, and meeting in October.

OHIO

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Radiological Society of the Academy of Medicine (Cincinnati Roentgenologists).—*President*, B. M. Warne, M.D., Doctors Building, Cincinnati; *Secretary-Treasurer*, Justin E. McCarthy, M.D., 707 Race St., Cincinnati, Ohio. Meetings held third Tuesday of each month.

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RHODE ISLAND

See New England Roentgen Ray Society.

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SOUTH DAKOTA

Meets with Minnesota Radiological Society.

TENNESSEE

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Tennessee Radiological Society.—President, Steve W. Coley, M.D., Methodist Hospital, Memphis; *Vice-president*, Eugene Abercrombie, M.D., 305 Medical Arts Bldg., Knoxville; *Secretary-Treasurer*, Franklin B. Bogart, M.D., 311 Medical Bldg., Chattanooga. Meeting annually with State Medical Society in April.

TEXAS

Texas Radiological Society.—President, Jerome H. Smith, M.D., San Antonio; *President-elect*, C. F. Crain, M.D., Corpus Christi; *First Vice-president*, M. H. Glover, M.D., Wichita Falls; *Second Vice-president*, G. D. Carlson, M.D., Dallas; *Secretary-Treasurer*, Henry C. Harrell, M.D., 517 Pine St., Texarkana. Meets annually. Temple is place of next meeting, Oct. 20 and 21, 1939.

VERMONT

See New England Roentgen Ray Society.

VIRGINIA

Radiological Society of Virginia.—President, Fred M. Hodges, M.D., 100 W. Franklin St., Richmond; *Vice-president*, L. F. Magruder, M.D., Raleigh and College Aves., Norfolk; *Secretary*, V. W. Archer, M.D., University of Virginia Hospital, Charlottesville.

WASHINGTON

Washington State Radiological Society.—President, H. E. Nichols, M.D., Stimson Bldg., Seattle; *Secretary*, T. T. Dawson, M.D., Fourth and Pike Bldg., Seattle. Meetings fourth Monday of each month at College Club.

WISCONSIN

Milwaukee Roentgen Ray Society.—President, H. W. Hefke, M.D.; *Vice-president*, Frederick C. Christensen, M.D.; *Secretary-Treasurer*, Irving I. Cowan, M.D., Mount Sinai Hospital, Milwaukee. Meets monthly on first Friday at the University Club.

Radiological Section of the Wisconsin State Medical Society.—Secretary, Russel F. Wilson, M.D., Beloit Municipal Hospital, Beloit. Two-day annual meeting in May and one day in connection with annual meeting of State Medical Society, in September.

University of Wisconsin Radiological Conference.—Secretary, E. A. Pohle, M.D., 1300 University Ave., Madison, Wis. Meets every Thursday from 4 to 5 P.M., Room 301, Service Memorial Institute.

EDITORIAL

LEON J. MENVILLE, M.D., *Editor*

HOWARD P. DOUB, M.D., *Associate Editor*

SOME PRESENT AND FUTURE PROBLEMS OF RADIOLOGY[1]

In contemplating the present status of radiology one is naturally led to consider the enviable position which this relatively youthful member of the medical profession occupies. It is just 43 years since Roentgen first saw the fluorescence of the crystals which his trained eyes correctly interpreted as the manifestation of hitherto unrecognized rays. That event transcends in importance any discovery made in our lifetime. It extended the spectrum of electromagnetic radiation to hitherto unbelievably shorter wave lengths. The ionization of air by x-rays led to the recognition of the electron. From the electron has come the radio and a host of mechanical devices that depend upon the electronic principle. This is in addition to the purely medical uses of x-rays, upon which the life and health of people depend to such a large degree.

Emerson has said that "An institution is the lengthened shadow of one man." It is readily apparent that the recognition and the physical characteristics of x-rays are the lengthened shadow of one man—Roentgen. However, the shadows cast by the roentgen rays of to-day were neither entirely foreseen nor brought to full fruition by that great scientist alone. A host of scientists and physicians have indelibly imprinted their shadows along the path of radiation until it stretches into fields undreamed of by its discoverer. Time is not available to discuss the part played by these individual men, but the epochal discoveries resulting from their labors have made radiology the great specialty that it is to-day. These discoveries were not made without the exaction of a terrific toll of suffering and death of many of these pioneers. This specialty is so new that most of us have known intimately one or more of these men who have suffered so silently the pain and anguish attendant on this condition.

Ours is a great heritage which has come down to us as a result of the labors and sufferings of a host of brilliant pioneers. These men have builded on the solid foundation of scientific facts By a combination of perseverance and ingenuity they have unearthed many of the hidden secrets of disease processes and made them visually perceptible. At the same time, these mysterious rays were applied as a curative agent in various disease processes until to-day it is difficult to determine in which field their greatest successes lie. We have here, then, a great bilateral diagnostic and curative agent, the like of which the world has never seen.

We owe a great debt to the pioneer workers in radiology and only by conscientiously attacking the present and future problems that hinder the progress of this work can we uphold the high standards which they set, and partly repay this debt. It behooves us, then, to attempt a careful analysis of the situation in which radiology finds itself at present and to plan by every means at our disposal to consolidate our present position and to adopt measures calculated to advance our position to the front ranks of the medical profession. What, then, shall we do to accomplish this aim?

First, we must induce the best of our interne groups to enter radiology for training. As the finished product so largely depends upon the raw material which goes into it, so must the future of radiology depend upon the young men who will enter its ranks for training. It is lamentable that radiology is not attracting a larger percentage of the outstanding young men from the student and interne groups to its fold. This is attributable to a number of factors, the chief of which is a feeling of the lack of economic security and the fear of domination by outside groups. In many instances it is apparent to these younger men that the position of the radiologist compares unfavorably with that of their medical and surgical confrérès. This is because of the fact that in some hospitals the management

[1] Presidential Address delivered before the Twenty-fourth Annual Meeting of the Radiological Society of North America, at Pittsburgh, Dec. 1, 1938.

dominates the radiologist to the point where effective leadership cannot be maintained, and thus passes naturally to the other groups. Such men often lose their initiative for research and teaching and lapse into a state of apathy and become medical technicians only. These men cannot favorably influence ambitious young men to enter a specialty in which such conditions exist.

Next we must provide more uniformly adequate training for these men who select radiology for their lifework. There are at present many training centers which are doing an excellent job of turning out men with basic training and adequate experience to begin their lifework in this specialty. Unfortunately these training centers are too few.

Training centers should exercise great care in selecting young men of good character, and of proven industry and ability, in their interne work. They must not accept more men than their teaching material justifies, and, above all, these men must not be exploited as a source of cheap help under the guise of training. We do not mean to imply that they should not do considerable routine work but that most of it should be of a medical nature and under the direct supervision of the radiologist.

We believe that three years should be the minimum period of training and that during that time some provision should be made for instruction in pathology. The exact amount of time and effort spent on that subject will depend upon the facilities available. We feel that didactic instruction is of little value in this type of post-graduate teaching and that students must learn the technic of using the library in their search for information on specific subjects. Short discussions of the radiologic principles involved in cases seen during the daily work should stimulate the student to search extensively in the literature for other opinions on the same subject.

The students should be expected to attend the various hospital staff meetings and clinical–pathological conferences. They should also be present at joint conferences between the department of radiology and the various clinical departments, as such conferences are invaluable in correlating the roentgen findings with the history and clinical data.

The division of time between diagnosis and therapy must be worked out according to the division of the subjects in the department. In no instance shall the instruction in radiotherapy be sublimated to that of diagnosis. We believe that instruction in radium therapy should be carried out coincidentally with roentgen therapy, as the two supplement each other so closely in the treatment of disease processes.

Finally, we should encourage our students to engage in at least one piece of research work during the course of their training in order that they may have the advantage of the guidance and friendly criticism of their instructors. Radiologists must continue their research work in the future as in the past, and these young men must be the future leaders to carry the banners of progress.

The next subject which engages our interest is the improvement of the relation of the radiologists to hospitals. It is now acknowledged that the practice of radiology constitutes the practice of medicine and is not a part of the corporate activity of the hospital. This position must be zealously guarded so that we may not lose that identity, especially when group hospitalization attempts to use our services without remuneration. The radiologist must be an accredited department head on the same basis as other specialties and should not be attached to, or be a part of, some other department. This has proven to be a great handicap in the past in many departments.

The financial arrangement between the hospital and the radiologist has been a source of endless discussion. No one plan is applicable to all situations. It is obvious that the problem of the small hospital varies widely from that of the large one, and the large private hospital from the teaching hospital. In various instances, the arrangements are on a salary basis, commission basis, or rental basis, with satisfaction both to the radiologist and to the hospital. If each side is careful not to exploit the other, or the patient, any of these plans can be made to function satisfactorily. The Pacific Roentgen Club has for some time fought diligently for the rental plan, which has the additional advantage of preserving the private practice of radiology. The care of non-pay patients would seem to be one of the pitfalls of this plan and a very definite stipulation as to the number of these patients should be in the contract to avoid unjust accusations from either side. This is probably the most equitable plan that can be drawn up to safeguard the rights of both parties. In those institutions in which all mem-

bers of the medical staff are on salary, it is obvious that the radiologist should be compensated in like manner.

A pernicious attempt has been made to divide the radiologic service into so-called technical and professional portions. If this plan were carried out to its ultimate absurdity, almost every medical specialty would soon feel the iron heel of lay domination, and radiology would cease to be an independent medical specialty. Another problem which has caused radiologists grave concern has been the attempt to include radiologic services as insurance benefits in group hospitalization plans. Happily, the American Medical Association has recognized the threatened danger to the entire medical profession and has unequivocally denounced both plans. This has given us powerful support in the fight, but even at this time new attempts are constantly being made to include our services in insurance plans without our permission. This should and will be resisted with all the power of organized radiology.

We have discussed, thus far, the relation of the radiologist to the hospital, but the relation of the private practitioner of radiology to radiology in general is one of which we must not lose sight. The rights of these men, in relation to the general medical profession and to the hospital, must be carefully guarded if we are to preserve individualism in radiology. In the early days of radiology, individualism was the rule, and many of the men whose names shine brightest in radiologic history were always private practitioners of radiology. The work they did with the crude apparatus of their day is the envy of all of us. Let us strive to preserve the private practice of radiology so that individualism which has done so much to develop the science of our specialty shall not disappear from our ranks.

Finally, we must insist on our rights to be considered as consultants. In this way only can we render the ultimate in service to the patient and the physician. This is our strongest bulwark against the inroads of the commercial laboratory and the "picture taker." It is also our opportunity to educate the clinician in what radiology has to offer to the general medical profession, and to show that the trained radiologist is indispensable in the modern care of the sick. The radiologist, because of his wide interest in every medical specialty, is able to bring to the consultation a knowledge that often enables him to read values from the film which illuminate the situation with startling clarity.

Radiology is a living science and thus is constantly changing. We must be on the alert to see that it keeps pace with the scientific accomplishments of other medical specialties. A great deal has already been done within our own ranks to keep radiology abreast of modern medicine. The Board of Radiology is functioning in a manner that cannot fail to reflect credit on radiology, and this will be increasingly so in the coming years. The closer co-operation among the several scientific societies in radiology is bearing fruit and radiology was never so strong nor so respected as it is to-day. The Inter-Society Committee is attacking our economic difficulties with a vigor that promises to solve many of these vexatious problems for us. The educational programs which the various societies have initiated will be a great force in the future to elevate the standards of practice in radiology and I am happy that it has been possible for this Society to begin a series of instruction courses this year, which should lead to a new and better type of service which this Society can render to its members in the future. Serious thought should be devoted to the question of the desirability of devoting a greater percentage of time on our future programs to this type of instruction.

In closing, may I again urge that all the members of our Society put the weight of their experience and prestige behind the efforts which your Officers and Committees are making toward elevating the science of radiology and preventing inroads on our specialty by outside groups.

HOWARD P. DOUB, M.D.
Detroit, Michigan

PRELIMINARY PROGRAM

THE ANNUAL MEETING of the RADIOLOGICAL SOCIETY OF NORTH AMERICA

ATLANTA, GA., December 11–15, 1939

"A New Apparatus for Demonstrating Duodenal Ulcer." ARTHUR R. BLOOM, M.D., Detroit, Mich.

"Methods of Analyzing Cancer Statistics." LEWIS G. JACOBS, M.D., Winona, Minn.

"Solitary Myeloma of Bone: A Review of the Literature and Report of Four New Cases." L. W. PAUL, M.D., and E. A. POHLE, M.D., Ph.D., Madison, Wisc.

"Roentgenological Considerations in the Diagnosis and Treatment of Primary Malignant Bone Tumors." WILLIAM E. HOWES, M.D., and SAMUEL G. SCHENECK, M.D., Brooklyn, N. Y.

"Non-tuberculous Inflammatory Lesions in the Lungs." A symposium arranged by HOWARD P. DOUB, M.D., Detroit, Mich.

"Adult Hilum Tuberculous Adenopathy." B. P. WIDMANN, M.D., H. OSTRUM, M.D., and J. FETTER, M.D., Philadelphia, Pa.

"Aneurysm of the Splenic Artery." HARRY HAUSER, M.D., and J. V. SEIDS, M.D., Cleveland, Ohio.

"Ventricular Deformities Caused by Brain Tumors." ROBERT S. STONE, M.D., and NICHOLAS S. PEDERSEN, M.D., San Francisco, Calif.

"Intracranial Collections of Lipiodol Following Lumbar Myelography." L. H. GARLAND, M.D., San Francisco, Calif.

"Roentgen Diagnosis of Acute Abdominal Conditions." A symposium arranged by LEO G. RIGLER, M.D., Minneapolis, Minn.

"Nuclear Physics in the Service of Medicine." A symposium arranged by ROBERT R. NEWELL, M.D., San Francisco, Calif.

1. "The New Alchemy." M. A. TUVE, Washington, D. C.
2. "The Use of Radio-active Elements in Physiological Research." WILLIAM BALE, Rochester, N. Y.
3. "What does Artificial Radio-activity Promise for Therapy?" JOHN LAWRENCE, M.D., San Francisco, Calif.
4. "A Preliminary Report on the Skin Reactions of Patients Treated with Fast Neutrons Generated by the Cyclotron." ROBERT S. STONE, M.D., and JOHN LAWRENCE, M.D., San Francisco, Calif.

"Internal Hernia: Two Operatively Verified Cases of Paraduodenal Hernia." VINCENT W. ARCHER, M.D., and GEORGE COOPER, M.D., University, Va.

"Pendant Mastography." DAVID E. EHRLICH, M.D., New York City.

"Physician, Know Thyself." RALPH E. MYERS, M.D., Oklahoma City, Okla.

"LUCKENSCHADEL (caput fenistratum, lacunar skull)." E. C. VOGT, M.D., and GEORGE WYATT, M.D., Boston, Mass.

"Sarcoid, with Slides of Chest Findings over a Period of Two Years." E. R. BADER, M.D., Cincinnati, Ohio.

"Peptic Ulcer: A Review of 1,000 Cases and a Follow-up Study of the Patients Diagnosed between Ten and Twenty Years Ago." MAURICE F. DWYER, M.D., and WILLIAM S. COLE, M.D., Seattle, Wash.

"Cardiovascular Dynamics: A Roentgen Kymographic Study." SAMUEL BROWN, M.D., J. E. MCCARTHY, M.D., and ARCHIE FINE, M.D., Cincinnati, Ohio.

"Therapy Records as They are Kept and as They Should be Kept." ROBERT R. NEWELL, M.D., San Francisco, Calif.

"Myelography with the Use of Thorium Dioxide Sol as a Contrast Medium" (lantern demonstration). B. H. NICHOLS, M.D., and WILLIAM A. NOSIK, M.D., Cleveland, Ohio.

"Roentgen Treatment of Diphtheria Carrier." IRA I. Kaplan, M.D., New York City.

"The Use of 200,000 Volts in the Treatment of Advanced Superficial Malignancy" (illustrated with colored lantern slides). JOHN T. MURPHY, M.D., and C. E. HUFFORD, M.D., Toledo, Ohio.

"Diagnosis of, and Roentgen Therapy for, Myelogenous Leukemia." WALTER C. POPP, M.D., and CHARLES H. WATKINS, M.D., Rochester, Minn.

"Treatment of Different Types of Malignancies Occurring on the Skin of the Face, with Particular Reference to the Selection of the Type of Irradiation that will Give the Best Results." FRANKLIN B. BOGART, M.D., Chattanooga, Tenn.

"Rotation Therapy." SYDNEY J. HAWLEY, M.D., Danville, Pa.

"Pre-operative Irradiation of Breast Carcinoma." EDMUND P. HALLEY, M.D., and PERRY J. MELNICK, M.D., Decatur, Ill.

"Radium Treatment of Carcinoma of Corpus Uteri: Description of a New Applicator." MILTON FRIEDMAN, M.D., New York City.

"Primary and Secondary Filters in Roentgen Therapy." L. D. MARINELLI, New York City.

"Late Injuries Following Irradiation." ZOE A. JOHNSTON, M.D., Pittsburgh, Pa.

"Induction by X-rays of Hereditary Changes in Mice." GEORGE D. SNELL, Bar Harbor, Maine.

"Studies in Protection of Radium Therapy Personnel." ROBERT E. FRICKE, M.D., and MARVIN M. D. WILLIAMS, Ph.D., Rochester, Minn.

"Surface, Depth and Exit Doses for X-rays in the Range from 100 to 200 kv." EDITH H. QUIMBY, M.A., L. D. MARINELLI, and MANUEL GARCIA, New York City.

"X-ray Protection." LAURISTON S. TAYLOR, Ph.D., Washington, D. C.

"A Million-volt X-ray Unit." Dr. E. E. CHARLTON, Schenectady, N. Y.

"Accumulative X-ray Effects in Cells." P. S. HENSHAW, Ph.D., Washington, D. C.

"Osteochondrosis." C. A. STAMMEL, LT. COL., M.C., U. S. Army, Fort Benning, Ga.

"Roentgen-ray Studies in Some Individuals Suffering from Low Back Pain: Lipiodol Studies before and after Operation." J. C. BELL, M.D., Louisville, Ky.

"Significance of Peristalsis of the Urinary Tract." J. P. KEITH, M.D., and E. L. SHIFLETT, M.D., Louisville, Ky.

"Sequelæ of Shoulder Dislocations." MAURICE D. SACHS, M.D., Portland, Oregon.

"Epithelioma of the Tonsil: Report of 162 Cases Treated with Radiation." W. L. MATTICK, M.D., Buffalo, N. Y.

"Contact Therapy." LOWELL S. GOIN, M.D., Los Angeles, Calif.

NEXT ANNUAL MEETING—REFRESHER SERIES

The schedule for the Refresher Series this year includes three hours Sunday afternoon, two hours Sunday evening, and two hours. from eight to ten, each morning of the Annual Meeting, December 11–15.

Several of the courses, particularly those subjects of wider scope, such as Radiology of the Gastro-intestinal Tract and Radiology of the Chest, are so arranged that related subjects will follow consecutively, making it possible to enroll in a sequential series. Basic presentations of Radiation Therapy will also be offered in series so that those with special interests may find Refresher Courses extending over the entire period of the series. The course on Physics of Radiation will be presented three hours on Sunday afternoon and two hours each morning of the meeting, and will follow the syllabus of lectures on the Physical Basis of Radiation Therapy, by Edith H. Quimby.

A formal announcement, with a description of each of the courses and its sequential relationship, will appear in the October issue of RADIOLOGY. There will be no enrollment fee. Members of the Society will be given preference and the number in the various courses will be limited by the size of the rooms available at the hotel.

Enrollment cards will be included in the annual letter which reaches the members of the Society thirty days prior to the Annual Meeting.

ATLANTA, PLACE OF 1939 ANNUAL MEETING[1]

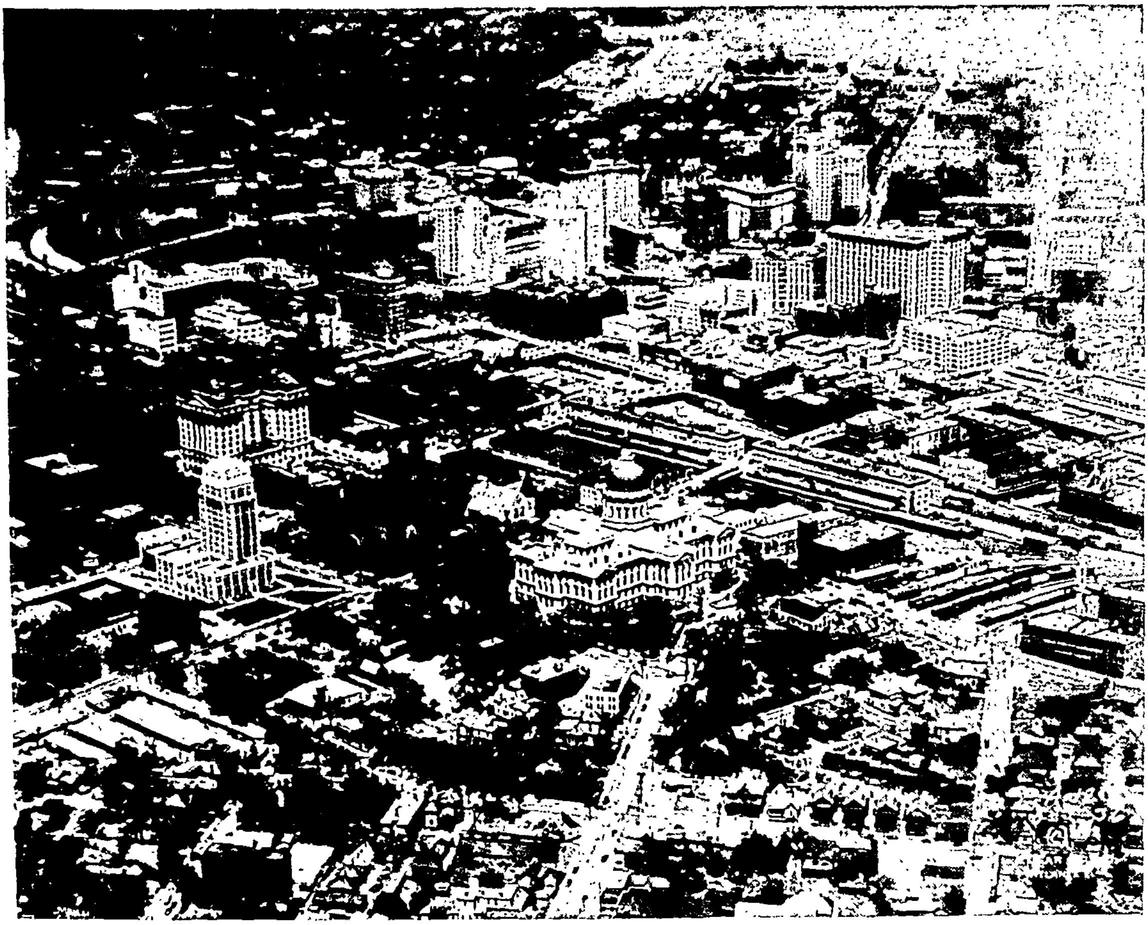
It has been said that Atlanta owes its existence to railroads, but it is also true that other modes of transportation have aided the city in its amazing growth. When the state-owned railroad, in 1833, selected a terminal site in the foothills of the Blue Ridge Mountains, the growth of the community could not have been visualized or it would have been given another name than Terminus. From the one family that inhabited the wilderness when the railroad came, the population grew rapidly; in 1843 the name was changed to Marthasville and in 1847 to Atlanta. It became the State Capitol in 1869.

Many factors have contributed to the growth of the young city, which has a population of 402,450 people, and an historical setting that makes it a mecca for tourists. The population is almost entirely native-born, the foreign element constituting less than 2 per cent. When the motor age came, good roads were provided and now a well-equipped airport is in service for mail, passenger, and commercial use. The location of the city and the geographical formation of the country 'round about it, make it a natural gateway between the North and West to the entire group of Southeastern States. Therefore, one railroad followed another, until eight railroad systems, with fifteen mail lines, converged here.

Atlanta has an altitude of 1,050 feet, the highest city of its size, or larger, east of the Mississippi River. The mean annual temperature is 61 degrees, and there are no extremes of heat or cold. Few persons stop to think that Atlanta is only a little south of the halfway mark between New York and Miami. (It is 864 miles to New York and 715 miles to Miami.)

The city is a center of activities for the

[1] The factual statements in this story were furnished through the courtesy of the Atlanta Convention and Visitors' Bureau.



Aerial view of Atlanta.

Federal Government in the Southeast. It is the home of the Fourth Corps Area, Department of War, and 36 other branch divisions, not including the emergency governmental agencies. The Federal Penitentiary houses 2,000 offenders.

Atlanta is a city of beautiful homes and all the essentials that go to make living a joy and comfort. The city has parks and playgrounds covering approximately 2,000 acres, five municipally owned golf courses, and nine private clubs' courses. Tennis, boating, and swimming are sports provided at all the clubs and parks, and afford Atlanta visitors interesting pastimes.

The city is surrounded by colleges and universities, being the home of Oglethorpe University, Emory University, Georgia School of Technology, Agnes Scott College, Marist College, Woodbury Hall, Washington Seminary, and Georgia Military Academy. There are more institutions for higher learning for colored people in Atlanta than in any other city in the world. Six schools of college rank specialize in the education of the negro.

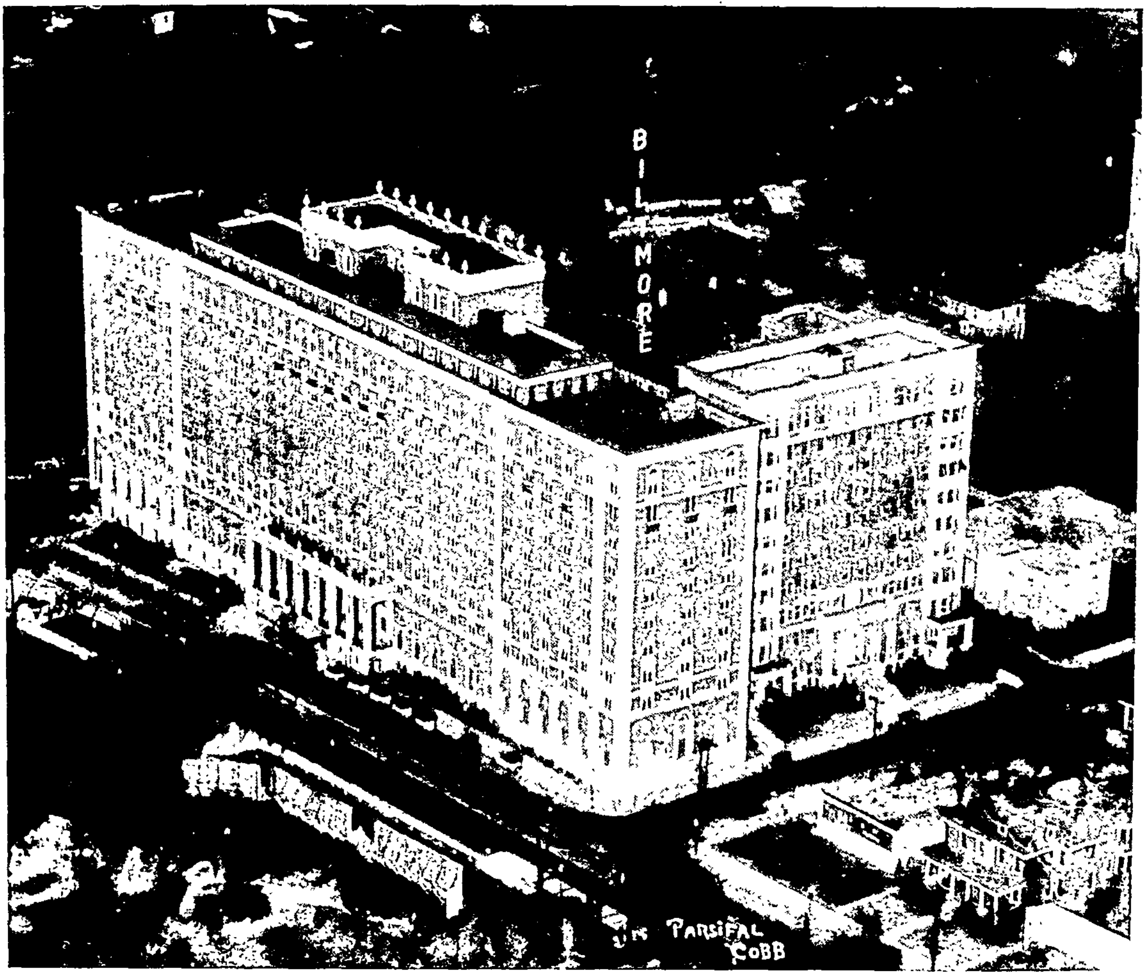
The visitors are always attracted by the points of interest in and around the city. Among these are: Wren's Nest, the home of Joel Chandler Harris, creator of "Uncle Remus"; the only exact replica of Bobby Burns' cottage in America; a cyclorama painting of the Battle of Atlanta, and Stone Mountain, a natural wonder, being five feet higher than the Woolworth Building.

The Radiological Society will hold its Annual Meeting at the Atlanta-Biltmore Hotel, from December 11 to 15, inclusive. Reservations should be made at once.

ANNOUNCEMENT

SIXTH INTERNATIONAL CONGRESS OF RADIOLOGY

Pursuant to the resolution passed in Chicago, in 1937, the Sixth International Congress of



The Atlanta-Biltmore Hotel, scene of the Next Annual Meeting of the Radiological Society of North America.

Radiology will take place in Berlin from July 31 to Aug. 4, 1940. It is proposed to use the Kroll Opera House for the sittings of the Congress. Members of radiological societies in all countries may become ordinary members of the Congress of Radiology, also persons recommended by radiological societies. As at previous Congresses, there will be general sessions and sectional sessions.

The following are some of the general subjects which are proposed for discussion: in diagnostics, "The modern development of special methods of examination in roentgen diagnostics and the results achieved with them" (automatism, cinematography, tomography, kymography, screen photography, contrast methods); in therapeutics, "The development of therapeutic methods, their achievements and the demarcation of their indications" (local and general radiation, quality of rays, time and space factors). It is further intended to give, in a series of connected lectures, a picture of the present state of knowledge as regards the effect of rays on the living cell (cell degeneration, mutations, impact theory), and also to make a report on the modern development of radiophysics. In addition, diagnostic and therapeutic results in individual spheres will be reported upon in connected lectures.

Beside the general lectures, departmental sessions will also be held, and the following subdivisions have been arranged for them: Roentgen diagnostics, radiotherapy, radiobiology, physics and technic, electrology and light.

Announcements of lectures must be sent to the President not later than Dec. 15, 1939. Extracts from papers, which should not exceed two typewritten pages of twenty-seven lines each, should be in the hands of the Secretary-

General not later than Feb. 1, 1940. The papers must be read by the author in person, who must be a member of the Congress.

Note concerning slides and films: Slides in the standard sizes $8^1/_2 \times 10$, 9×12, $3^1/_4 \times 4^1/_4$ can be shown. In the case of sizes other than these, it is necessary to send in an inquiry. Cinematographic films of 8 and 16 mm. widths can be projected.

The Rally is connected with an industry exhibition in the Zoo (inquiries should be sent to Mr. Kreykenbohm, Wirtschaftsgruppe Elektroindustrie, Fachabteilung "Elektromedizin," Berlin W 35, Corneliusstr. 3), and with a Book Show.

For all further details, you are requested to communicate with the Secretary-General. A detailed letter of invitation will be dispatched toward the end of the year.

Prof. Dr. H. Holthusen, *President*,
Hamburg 20, Goernestr. 29
Prof. Dr. W. Baensch, *Secretary-General*,
Leipzig C 1, Liebigstr. 20
Dr. med. h. c. B. Hauff, *Treasurer*,
Leipzig C 1, Rossplatz 12

COMMUNICATION

CANADIAN ASSOCIATION OF RADIOLOGISTS

The Canadian Association of Radiologists held its third Annual General Meeting at the Windsor Hotel, in Montreal, on June 22 and 23, with an attendance of between fifty and sixty members. The agenda of the Association was as usual limited to matters of business, the scientific sessions of Canadian radiologists being conducted through the Section of Radiology of the Canadian Medical Association. The main matters of discussion at the meeting were Relationship of Radiologists to Institutions in Contract Radiological Practice, and the matter of Inclusion of Medical Fees, Notably Radiological Fees, in Group Hospitalization Plan. Suitable resolutions were adopted by the Association and definite progress was made.

The membership of the Association now comprises 122, divided as follows: regular members, 98; members-elect, 16; associate members, 6; honorary members, 3. A. H. Pirie, M.D., of Montreal, was elected to Honorary Membership, the other two Canadian radiologists previously elected to Honorary Membership being M. H. Tovell, M.D., of Toronto, and Leo Pariseau, M.D., of Montreal. J. E. Gendreau, M.D., of Montreal, was elected the new President of the Association, W. H. McGuffin, M.D., of Calgary, Alberta, Vice-president, A. C. Singleton, M.D., of Toronto, was re-elected as Honorary Secretary-Treasurer. W. A. Jones, M.D., of Kingston, was elected Chairman of the Interrelations Committee.

IN MEMORIAM

WILLIAM J. MAYO, M.D.

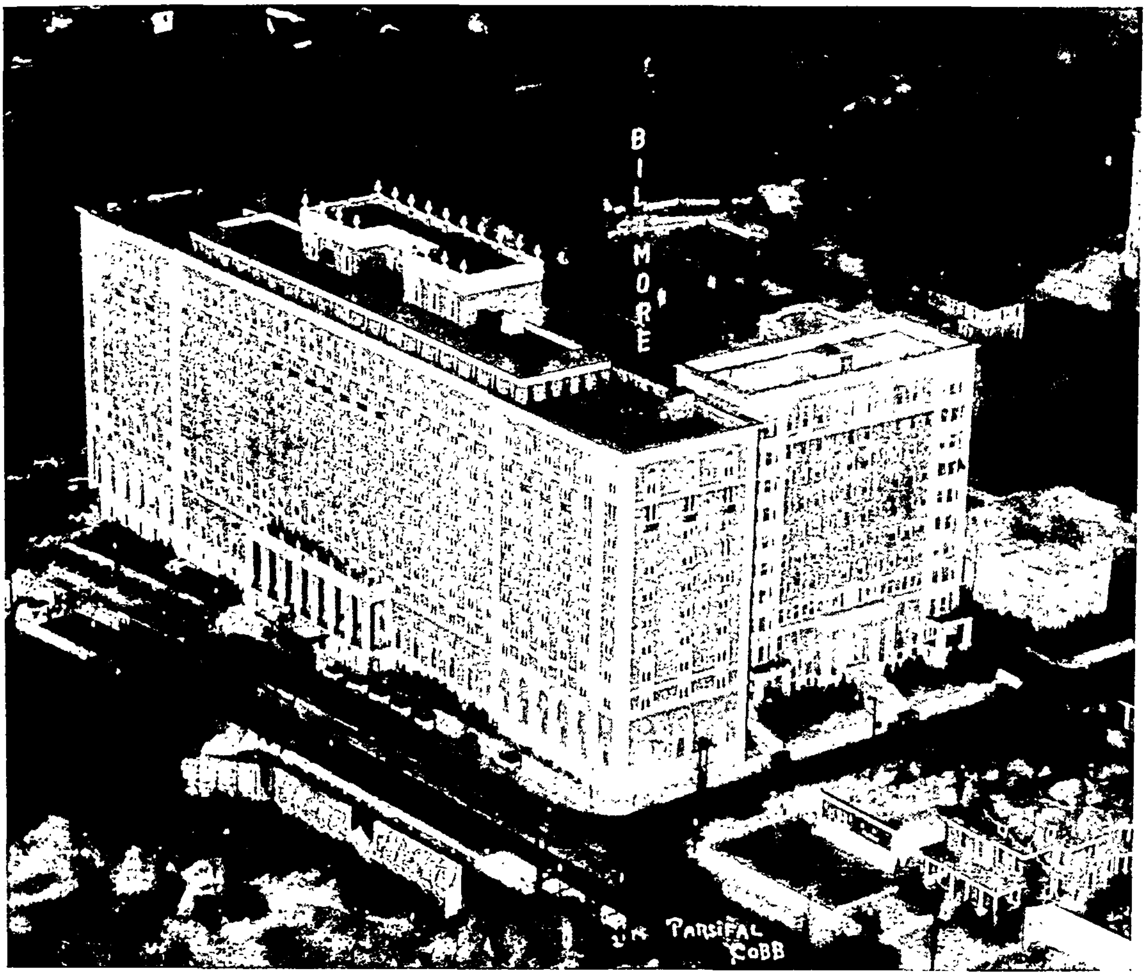
Dr. Mayo, master surgeon that he was, was so thoroughly in sympathy with the developments in radiology that he delivered the opening address before the Fifth International Congress of Radiology. He said in part:

"Medicine and surgery find themselves fortified by relatively new agents which day by day are being used increasingly in the treatment of disease. We recognize that in certain situations advanced cancer, which is beyond reasonable possibility of cure by the knife, can with but little risk be treated with radiant energy in the form of x-rays and radium, and even cured, if it has not progressed beyond the immediate site. We find that certain cellular tumors which are extremely active in growth can be treated with radiology with better results than with surgery, and without serious risk. This new agent, which began as an aid to surgery and medicine, extends its usefulness day by day."[1]

The biographical facts of Dr. Mayo's career are well known to all readers of RADIOLOGY, doubtless—in the main facts they parallel those in the life of his celebrated brother, Charles, who has just passed on. Let us, therefore, review briefly those incidents, honors, and interests which were peculiarly "Dr. Will's" own.

It has been said that William physically resembled the father, and he early adopted his father's way of life and some of his father's attitude toward life, which was expressed in the quotation, "He loved the truth and sought to know it." In his boyhood, too, he began to acquire those habits of industry that were to remain with him throughout life. At all events, he soon plunged into work; not odd jobs, such as most boys pick up, but medical

[1] RADIOLOGY, 30, 647–649, May, 1938.



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The following are some of the general subjects which are proposed for discussion: in diagnostics, "The modern development of special methods of examination in roentgen diagnostics and the results achieved with them" (automatism, cinematography, tomography, kymography, screen photography, contrast methods); in therapeutics, "The development of therapeutic methods, their achievements and the demarcation of their indications" (local and general radiation, quality of rays, time and space factors). It is further intended to give, in a series of connected lectures, a picture of the present state of knowledge as regards the effect of rays on the living cell (cell degeneration, mutations, impact theory), and also to make a report on the modern development of radiophysics. In addition, diagnostic and therapeutic results in individual spheres will be reported upon in connected lectures.

Beside the general lectures, departmental sessions will also be held, and the following subdivisions have been arranged for them: Roentgen diagnostics, radiotherapy, radiobiology, physics and technic, electrology and light.

Announcements of lectures must be sent to the President not later than Dec. 15, 1939. Extracts from papers, which should not exceed two typewritten pages of twenty-seven lines each, should be in the hands of the Secretary-

moneys and properties never can inure to the benefit of any individual. Records of deeds may become buried in archives, but the living institution which these men founded and the permanence of which they provided for, presumably will endure as long as Minnesota and the nation of which it is a part endure.

Scientific organizations made awards to Dr. Will. No detailed mention can be made here of the score or so of honorary academic degrees that were conferred on him. In addition to the posts of honor in foreign and American academic fraternities, Dr. Will was a member of twenty-seven medical organizations in this country and abroad.

Dr. Will was a great believer in the short siesta. He practised it himself for many years, and if that is the way to come through in as good condition as was his, for so many years, this country as a whole would do well to adopt the practice. Wherever he was, it was evident that Dr. Will's favorite companion was the calm, self-contained, dignified, great lady, Mrs. Mayo, who before her marriage, in 1884, was Miss Hattie Damon, of Rochester.

HENRY K. PANCOAST, M.D.

A fitting memorial to the late Henry K. Pancoast, M.D., is being prepared, to be published in the next issue of RADIOLOGY.

BOOKS RECEIVED

Books received are acknowledged under this heading, and such notice may be regarded as an acknowledgment of the courtesy of the sender. Reviews will be published in the interest of our readers and as space permits.

GRUNDLAGEN DER RÖNTGENDIAGNOSTIK UND RÖNTGENTHERAPIE (Principles of Roentgen Diagnosis and Roentgen Therapy). By DR. G. SCHULTE, Chief Physician of the Knappschafte Hospital in Recklinghausen and DR. F. KUHLMANN, of the medical clinic at the University of Halle. A monograph of 140 pages, with 148 illustrations. Published by Georg Thieme, Leipzig, 1939. Price: 8.50 R.M. bound.

CANCER OF THE COLON AND RECTUM: ITS DIAGNOSIS AND TREATMENT. By FRED W. RANKIN, B.A., M.A., M.D., Sc.D., F.A.C.S., Surgeon, St. Joseph's and Good Samaritan Hospitals, Lexington, Kentucky; and A. STEPHENS GRAHAM, M.D., M.S. (in Surgery), F.A.C.S., Surgeon, Stuart Circle Hospital, Richmond, Virginia, Assistant Professor of Surgery, Medical College of Virginia. A volume of 358 pages with 133 figures. Published by Charles C. Thomas, Springfield, Illinois, 1939. Price: $5.50.

ROENTGEN TECHNIC. By CLYDE MCNEILL, M.D., Louisville, Kentucky. A volume of 315 pages, with 268 illustrations and numerous tables. Published by Charles C. Thomas, Springfield, Illinois, 1939. Price: $5.00.

DIE HERZKRANKHEITEN, KLINIK, RÖNTGENBILD UND ELEKTROKARDIOGRAMM (Diseases of the Heart, Clinical, Roentgenologic, and Electrocardiographic aspects). By Dr. PAUL UHLENBRUCK, Professor in the University of Cologne; Chief Physician in the medical division of St. Elizabeth's Hospital and German Charity Institute for Health at Cologne. Second edition. A volume of 422 pages with 413 illustrations. Published by Johann Ambrosius Barth, Leipzig, 1939. Price: 38.00 R.M. bound (25 per cent discount allowed to foreign purchasers).

LEHRBUCH DER RÖNTGENOLOGISCHEN DIFFERENTIALDIAGNOSTIK DER ERKRANKUNGEN DER BRUSTORGANE (Roentgenologic Differential Diagnosis of Diseases of the Thoracic Organs). By Dr. WERNER TESCHENDORF, Chief Physician of the Radiation Institute, General Hospital, Cologne. A volume of 803 pages with 891 illustrations. Published by Georg Thieme, Leipzig, 1939. Price: paper, 69.00 R.M.; bound, 71.00 R.M. (25 per cent discount allowed to foreign purchasers).

RADIOLOGIE CLINIQUE DU COEUR ET DES GROS VAISSEAUX (Clinical Radiology of the Heart and Great Vessels). By C. LAUBRY, P. COTTENOT, D. ROUTIER, and R. HEIM DE BALSAC. Two volumes totalling 334 pages, with 1049 figures and drawings. Published by Masson et Cie, Paris, 1939. Price: Two volume export edition—430 francs.

L'ELECTRO ENCEPHALOGRAMME (Electro-encephalogram): NORMAL AND PATHOLOGIC. By IVAN BERTRAND, Director of the School of Hautes Etudes; JEAN DELAY, Hospital Physician, Hospital of Paris, and JACQUELINE GUILLAIN, Assistant in the Neurological Institute. A volume of 294 pages with 94 figures. Published by Masson et Cie, Paris, 1939. Price: 90 francs.

BOOK REVIEWS

LEUCHTSCHIRMPHOTOGRAPHIE RÖNTGENREIHENUNTERSUCHUNG (A Method of Roentgen Examination by Photographing the Shadow Structures on a Fluoroscopic Screen). By Prof. Dr. ROBERT JANKER, Bonn a. Rh. A volume of 57 pages, with 58 illustrations. Published by Johann Ambrosius Barth, Leipzig, 1939. Price: 9.00 R.M.

An excellent and rather comprehensive handling of the subject, especially as applied to pulmonary tuberculosis. Historical data are recorded since 1896 and emphasis is placed on work done since 1933. The author discusses the fundamental factors pertaining to fluorescent screen, lens, and micro-film adaptable to this work. He emphasizes its low cost for large group surveys, its economy in filing space and record keeping, and finally gives lay-outs for rooms and motorized trailers for portable work. His main development is toward the making of 24 × 24 mm. films of the chest, to be re-magnified for reading at a convenient size.

He does not anticipate that the micro-film will displace the standard full-sized film except for the case-finding programs of tuberculosis.

ERGEBNISSE DER GESAMTEN TUBERKULOSE-FORSCHUNG (Results of the Entire Research on Tuberculosis). Edited by H. ASSMANN, H. BEITZKE, and H. BRAEUNING. A volume of 577 pages, with 135 illustrations and several colored plates. Published by Georg Thieme, Leipzig, 1939. Price: bound, 58.00 R.M. (25 per cent discount allowed to foreign purchasers).

This volume contains nine contributions prepared in monographic form and dealing with certain phases of tuberculosis. While undoubtedly the book is written primarily for the physician specializing in this field, several chapters contain sufficient references to diagnostic roentgenology and occasionally to radiation therapy to be of interest to the radiologist.

L. Hantschmann, who is working in the medical clinic of the University of Königsberg under the well-known H. Assmann, discusses a special type of sclerosing tuberculosis, which is histologically characterized by the presence of a peculiar large-celled hyperplasia described by Mylius-Schuermann and others. It produces a definite clinical picture as it involves the various organs, and in the lungs it simulates roentgenologically lymphangitis carcinomatosa. The essays on tuberculosis of the the nose and pharynx by F. Zöllner (Jena) and of the ear by A. Brüggemann (Giessen) both offer advice on the use of radiation in the treatment of these conditions. A chapter by E. Randerath (Düsseldorf) dealing with the pathological anatomy of tuberculosis of the larynx precedes the discussion of its clinical aspect by L. Rickmann (Ziegenhals). Of special interest are the relationship between tuberculosis of the larynx and lungs, the roentgen diagnosis of the laryngeal lesions, and the place of radiation in their treatment. Roentgen therapy in small doses (10 per cent S.E.D.) is beneficial and definitely analgesic. H. Schleussing (Munich) gives a good review of our present knowledge of the pathologic anatomy of tuberculosis of the urinary and male genital tracts, the clinical part being ably outlined by H. F. J. Weber (Vienna). While roentgen rays are now indispensable in the diagnosis of renal tuberculosis, they have not proved efficacious in its treatment. How valuable the proper use of roentgen rays as a guide in therapy can be is clearly shown in the chapter by H. Kleesattel (Rogzow) entitled "Extrapleural Pneumothorax and Oleo-pneumothorax." In the author's experience the method has proved especially advantageous in children. An analysis of the psychology of the tuberculous patient and steps to influence it, by H. Boening (Giessen) and H. Braeuning (Hohenkrug), points out the importance of adequate mental guidance in any program of anti-tuberculosis activities.

Each contribution is accompanied by a well-selected bibliography and the illustrations are excellent.

RÖNTGENATLAS DER ERKRANKUNGEN DES HERZENS UND DER GEFÄSSE. (Roentgen Atlas of Diseases of the Heart and Vessels.) Second edition. A monograph of 161 pages. Published by Urban & Schwarzenberg, Berlin, 1939. Price: 12.00 R.M. bound (25 per cent discount to foreign purchasers).

This interesting work is published primarily for the general practitioner. It is, as the title suggests, an atlas, containing 90 illustrations with an excellent text. The divisions of the book include an introduction, discussions of technics, the normal heart, the diseased heart, diseases of the pericardium, and diseases of the vessels. The subject matter is concerned with ordinary roentgenographic material, *i.e.*, the so-called six-foot heart radiograph, oblique views together with occasional lateral views and esophagograms. Kymography is referred to as more of an academic than as a practical procedure and is not stressed. The section on diseases of the blood vessels is confined to aortic diseases, and arteriosclerosis with calcification is seen as an incidental finding in other parts of the body. It is of interest that the

classic heart measurements (ML, MR, etc.) are mentioned only to minimize them since the author believes that there are many extraneous factors which alter their value. The variations of the normal heart are discussed quite extensively. The author is satisfied to refer to an increase of heart size from the general impression, rather than absolute measurement. Case histories, confirmed whenever possible, are used in presenting the material. Plastic models are used to illustrate morphologic changes in the cases discussed. The classic alterations in the heart shadow following valve changes incident to rheumatic heart disease are quite thoroughly shown. It is interesting to note that the author speaks rather glibly of a "mitral lung" which is a manifestation of increased lung markings due to greater pressure in the pulmonary circulation, occurring in mitral heart disease. Hypertensive and arteriosclerotic heart disease, syphilitic heart disease, and congenital heart disease are also discussed. The author feels that one cannot always make an absolute diagnosis in cases of congenital heart disease since there often is a multiplicity of lesions which produce bizarre changes in the cardiac silhouette. Cases of hyper- and hypothyroid heart disease and the rarer types of cardiac changes, such as seen in beri-beri, etc., are not discussed. The section on pericardial lesions is representative of the excellent manner in which the individual case histories are presented. As stated above, special technics are not introduced, hence arteriography is not mentioned, and the section on arterial disease thus is somewhat limited. One has the opinion after studying this worthwhile volume that there is a great deal of information which can be obtained by relatively simple radiographic methods which should be of value not only to roentgenologists but to cardiologists and general practitioners who are required to interpret their own roentgenographs.

Atlas of Skeletal Maturation. By T. Wingate Todd, M.B., Ch.B. (Manc.); F.R.C.S. (Eng.). A volume of 202 pages, with 35 illustrations. Published by C. V. Mosby Company, St. Louis, 1937. Price: $7.50.

This work culminates one of the most painstaking and comprehensive studies of skeletal maturation as related to child development that has been undertaken. Doctor Todd and his associates in compiling this material reviewed thousands of roentgenograms and as is quite evident from the text, every possible care was used in determining and selecting the various age standards. The standards cover the period from three months after birth to the age of sixteen years in girls and nineteen years in boys, at which dates symbols or determinators of maturity provided by growing shaft surfaces, epiphyses related to these, and cartilage bones of the wrist cease to register progress.

The standards chosen to represent successive stages in maturity by intervals of three months to the end of the first year and by six-month intervals thereafter represent the accumulated roentgenographic records of Cleveland children from all grades of society, except the destitute, without regard to nationality of origin, type of family line, stature, and weight. The standards themselves are picked from groups of children of white stock ultimately of European origin. They are nevertheless applicable to children of negro parentage, for it has been shown that there is no practical distinction in determinators or in age relationships of maturation phase to differentiate white from colored children of similar social standing.

This volume should be of great interest to all those who are concerned with roentgenology of the skeletal system, for it will undoubtedly remain as an accepted standard for some time to come. The material is presented in a highly scientific manner and affords a great insight to a subject concerning which the average roentgenologist has a rather limited concept.

Lehrbuch der Röntgendiagnostik (Textbook of Roentgenologic Diagnosis). By H. R. Schinz, W. Baensch, and E. Friedl. A text consisting of 2,182 pages, 2,810 illustrations, and 13 photographic plates, published as two volumes of two parts each, by Georg Thieme, Leipzig, 1939. Price: 270 R.M. bound (25 per cent discount allowed to foreign purchasers).

This the fourth edition of an internationally known comprehensive treatise of roentgenologic diagnosis that is rapidly taking on the cloak of a veritable encyclopedia concerning the subject. There is nothing comparable to it in any language at the present time. The present edition is entirely rewritten and reset and consists of 2,182 pages, an increase of

ANNUAL MEETING

THE RADIOLOGICAL SOCIETY OF NORTH AMERICA, INC.

DECEMBER 11 to 15, 1939

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OFFICIAL NOTICE

MEMBERS OF THE RADIOLOGICAL SOCIETY OF NORTH AMERICA

The By-Laws Committee offers for adoption the following amendment to Article V, Section 10: (to be added at the end of the present Section 10)

> "The Executive Committee may from time to time select and appoint or approve the selection and appointment of four or less members of this Society as members and trustees of the American Registry of X-Ray Technicians in accordance with the By-laws of the said Registry; but this Society shall not assume any responsibility or liability for the acts or omissions of said members and trustees or any of them, and the Secretary-Treasurer of this Society shall not be responsible or accountable for the funds or supervision of the funds of the said Registry."

Respectfully submitted,
COMMITTEE ON BY-LAWS
William J. Corcoran, M.D., *Chairman*
Lowell S. Goin, M.D.
Donald S. Childs, M.D.

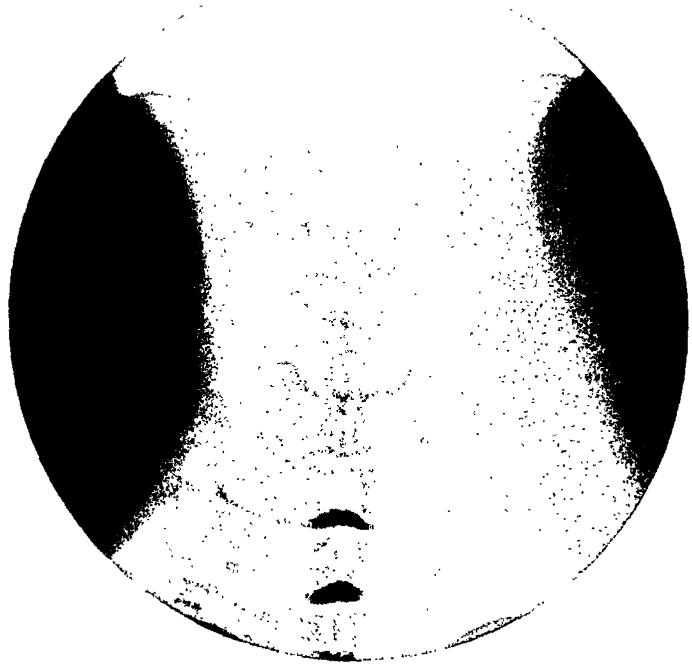
This notice is published to comply with Article XV, Section 1 of the By-Laws of the Radiological Society of North America.

Donald S. Childs, M.D., *Secretary-Treasurer*

All resolutions to be acted upon at the annual meeting in Atlanta, Georgia, should be presented to the RESOLUTIONS COMMITTEE before the Executive Sessions.

Lowell S. Goin, M.D., *Chairman*
Edward P. McNamee, M.D.
Orion O. Feaster, M.D.

1



2

3

***Technical Factors for Radiographs Reproduced on Reverse Side of this Page* . . . Examination of Cervical Spine**

	1	2	3
POSTURE	Erect	Supine	Supine
PROJECTION	Lateral	Anteroposterior	Anteroposterior
THICKNESS	10 cm.	11 cm.	11 cm.
ANODE-FILM DISTANCE	72″	30″	30″
P-B DIAPHRAGM	None	5-1 grid-ratio	5-1 grid-ratio
TUBE FOCAL SPOT		.8 mm.*	
FILTER		1 mm. aluminum*	
FILM		Eastman *Ultra-Speed**	
SCREENS		Eastman *High-Definition**	
KV.P.	70	55	65
MA.S.		75*	
DEVELOPMENT		Kodalk X-ray Developer (3½ min., 65° F.)*	
FIXATION		Eastman X-ray Fixer*	

*This factor applies to all three radiographs

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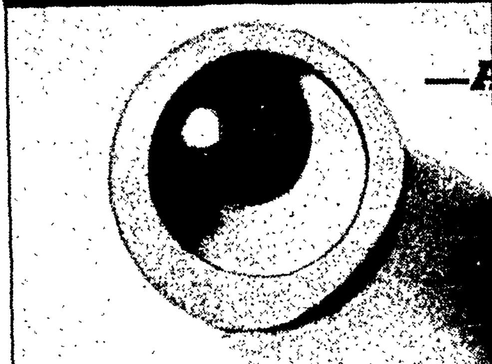

FIG. 1. New unused bearing ball of type manufactured expressly for use in rotating-anode tubes. (Magnified.)

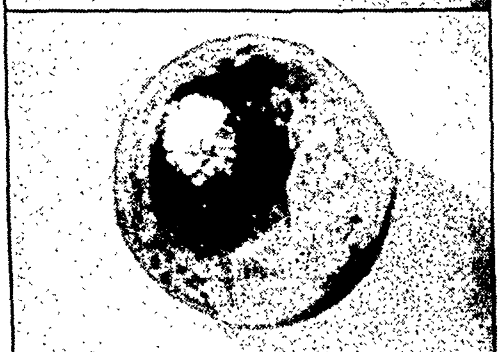

FIG. 2. The same ball when bearing failed after 96 hours' operation in DYNAMAX Rotating Anode Tube. Ravaged surface indicates intense friction encountered.

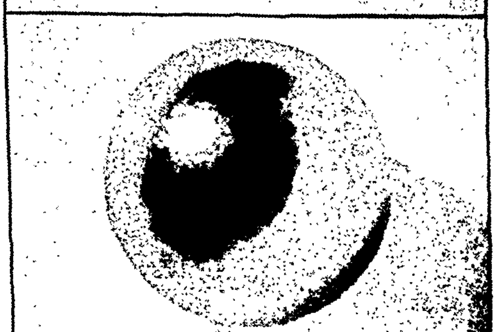

FIG. 3. Machlett-DYNAMAX ball* after 500 hours' operation. Special process developed by Machlett applied to new ball (Fig. 1) greatly reduces friction, multiplies wear-resistance.

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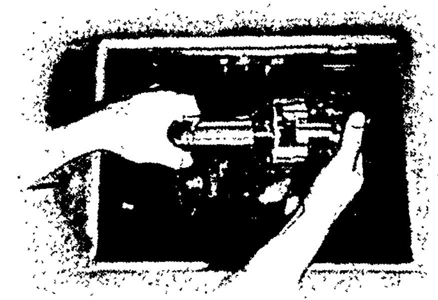

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RADIOLOGY

A MONTHLY JOURNAL DEVOTED
TO CLINICAL RADIOLOGY AND
ALLIED SCIENCES

DECEMBER · 1939

VOLUME 33 NUMBER 6

Owned and Published by THE RADIOLOGICAL SOCIETY
OF NORTH AMERICA *as its Official Journal*

RADIOLOGY

A MONTHLY JOURNAL DEVOTED TO CLINICAL RADIOLOGY AND ALLIED SCIENCES

GENERAL INFORMATION

RADIOLOGY is entered as second class matter at Syracuse, New York, and Easton, Penna., under the Act of August 24, 1912, and accepted November 24, 1934. RADIOLOGY is published by the Radiological Society of North America as its official Journal. Subscription rate $6.00 per annum. Canadian and foreign postage, $1.00 additional. Single copies, 75c each. All correspondence relative to business matters connected with the Radiological Society of North America and RADIOLOGY, or remittance for non-member subscriptions, should be made payable to the Radiological Society of North America and should be addressed to the Secretary-Treasurer, Donald S. Childs, M.D., 607 Medical Arts Building, Syracuse, New York. In requesting change of address, both the old and the new address should be given.

RADIOLOGY is published by the Radiological Society of North America, under the supervision of a Publication Committee, who reserve the right to reject any material submitted for publication, including advertisements. All correspondence relating to publication of papers should be addressed to the Editor, *Leon J. Menville, M.D., 1201 Maison Blanche Bldg., New Orleans, Louisiana.* Original articles will be accepted only with the understanding that they are contributed solely to RADIOLOGY. Articles in a foreign language will be translated if acceptable. Manuscripts should be typewritten, double spaced, with wide margins, on good paper, and the original, not a carbon copy, submitted. It is advisable that the author keep a carbon copy, as used manuscripts will not be returned. The author's full address should appear on the manuscript. Photographic prints should be clear and distinct and on glossy paper, preferably mounted. Drawings and charts should be in India ink on white paper. Blueprints will not reproduce satisfactorily. All photographs and drawings should be numbered, the top should be indicated, and each should be accompanied by a legend with a corresponding number. Authors are requested to indicate on prints made from photomicrographs the different types of cells to which attention is directed, by drawing lines in India ink and writing in the margin. The lines will be reproduced, and the words will be set in type.

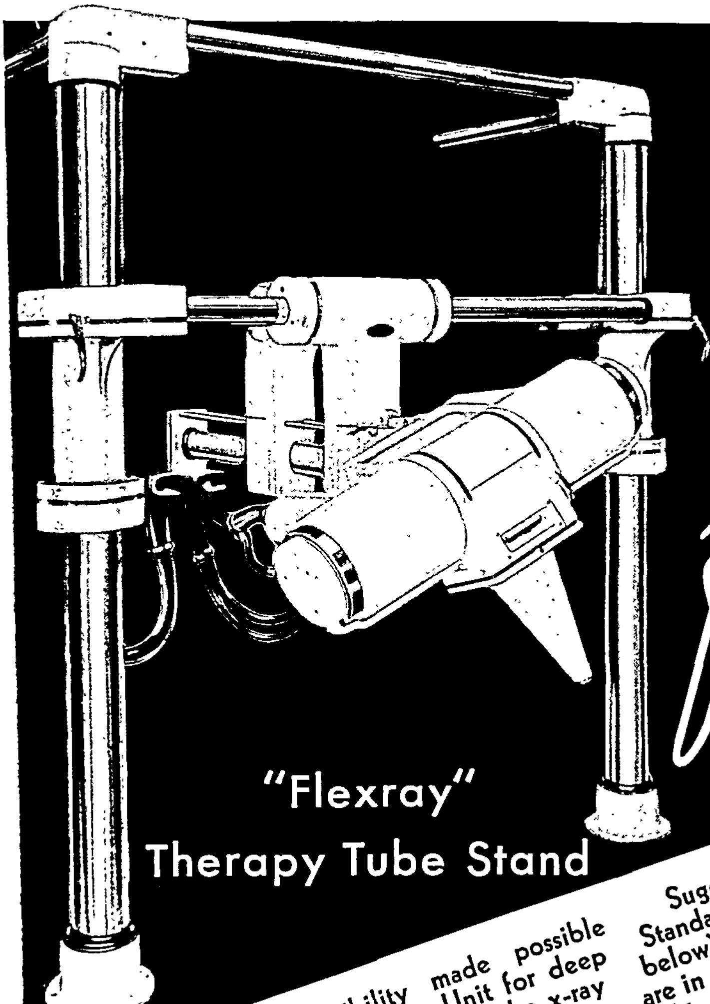
The Society will furnish a limited number of cuts and fifty reprints to authors but arrangements must be made with the Editor for the illustrations and reprints. Please address all orders for reprints to the *Radiological Society of North America, 607 Medical Arts Bldg., Syracuse, New York.*

Rate for "want" advertisements for insertion in Classified Section is 8 cents per word, minimum charge $2.00. Remittance should accompany order. Rates for display advertisements furnished upon request.

Dues to the Radiological Society of North America include subscription to RADIOLOGY and should be paid to *Donald S. Childs, M.D., Secretary-Treasurer, 607 Medical Arts Bldg., Syracuse, New York.*

Inquiries regarding the program of the meeting of the Society for the current year should be sent to the President.

The Editor accepts no responsibility for the opinions expressed by the contributors. We endeavor to publish the papers as submitted, reserving the right to introduce such changes as may be necessary to make the contributions conform to our editorial standards.



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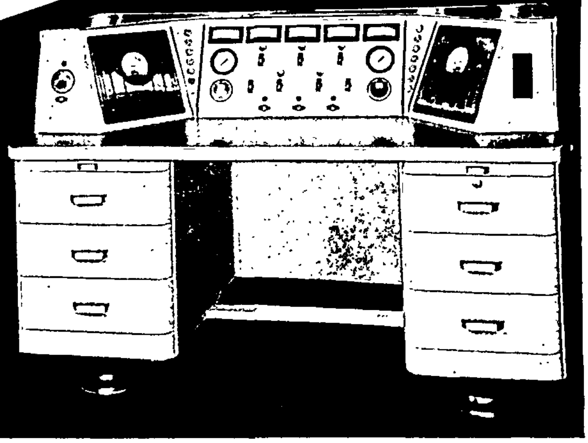

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RADIOLOGY

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PUBLISHED BY THE RADIOLOGICAL SOCIETY OF NORTH AMERICA

33 DECEMBER, 1939 No. 6

CLINICAL AND NEUROLOGICAL ASPECTS OF LOW BACK AND SCIATIC PAIN[1]

By MAURICE N. WALSH, M.D., Section on Neurology, The Mayo Clinic, *Rochester, Minnesota*

THE patient with intractable low back and sciatic pain always has been a problem to the physician. Lumbago and sciatica are ancient conditions; Hippocrates is known to have advised the use of the actual cautery in the treatment of patients afflicted with these conditions. The use of the actual cautery, at least by many of the ancient and medieval physicians, seems to have been reserved for the treatment of those conditions for which the physician had very little else to offer; and use of the hot iron probably accomplished the purpose of allowing the physician to feel that he was doing something in a difficult situation, at the same time terrifying the patient to such extent that he stayed away from the physician and refrained from bothering him with his troublesome complaints.

To-day, physicians are more fortunate in that they can offer the patient suffering from this painful condition more effective methods of treatment. Low back and sciatic pain, however, are still responsible for a tremendous economic loss each year, so that accurate diagnosis of the condition and proper treatment of the patient are important. Recently the anatomy, physiology, and pathology of the various structures composing the lumbosacral region of the spinal column and pelvis have been carefully studied in the hope of determining the cause of this distressing symptom of pain in the lower part of the back and along the course of the sciatic nerve and of finding suitable treatment for the condition responsible for it. It is interesting to note that several investigators, approaching the problem from different aspects, have found causes for this pain which have sufficed to satisfy the investigators and their followers that they have located the source of the trouble in at least some cases. It is impossible in this brief period of time to mention all these various contributions and their originators.

But I may call attention, in passing, to the work of Ghormley on what is called the "facet syndrome" (arthritis of the facets); of Ober on sciatic pain due to tense fascia lata; of Towne and Reichert; of Spurling and associates; and of Brown on treatment of hypertrophy of the ligamenta flava by compression of the nerve root; of Goldthwait, and Middleton and Teacher, and Mixter and Barr, and Hampton, and Robinson, and Love, Camp, and the author (2, 3, 9, 10, 11, 18), not to mention many others, on the production of low back and sciatic pain by posterior protrusion

[1] Presented before the Twenty-fourth Annual Meeting of the Radiological Society of North America, at Pittsburgh, Nov. 28–Dec. 2, 1938.

of an intervertebral disc; and also of Steindler on the production of low back and sciatic pain by irritation of the posterior divisions of spinal nerves originating in pathologic processes in muscles and ligaments; and of Gratz on the production of this type of pain by fascial adhesions. Proper evaluation of all these so-called "syndromes" will take many years.

At present, the most promising of the aforementioned beliefs relative to the causes of low back and sciatic pain is that concerning posterior protrusion of the intervertebral discs of the lumbar region, which I shall discuss briefly below. That new conceptions of the causes of this condition will be evolved seems likely. The problem is complex, and further study of it is certain to be productive. This much, however, is certain: that day is past in which the patient complaining of severe sciatic or lumbar pain was adjudged to be suffering from "sacro-iliac strain" or "sacro-iliac arthritis," and was treated by spinal fusion. Low back and sciatic pain are symptoms, and considered in conjunction with other symptoms and signs, they permit classification of the causative factors and the proper diagnosis and treatment in a large number of cases.

The possible causes of, or contributing factors to, the production of low back and sciatic pain are: congenital anomalies, trauma, tumors, infection, postural defects, and psychogenic factors. It is important to realize that the symptoms and signs presented by the patient may have multiple causes, and that more than one of the factors mentioned may be at work. Congenital skeletal anomalies are not uncommon in the lower lumbar and sacral regions of the spinal column. They are frequently benign and may often appear to have no significance. At the Mayo Clinic, in a series of 300 cases in which posterior protrusion of an intervertebral disc was proved at operation, minor skeletal anomalies have been seen frequently. Congenital, vascular, intraspinal anomalies are seen occasionally, and they usually present the clinical picture of a tumor of the spinal cord or cauda equina. Consequently, the physician should not infer that with the finding of a congenital anomaly in roentgenologic studies of the lumbar or sacral regions of the spinal column, the cause of the sciatic or low back pain of which the patient complains, has been found. It is probable that congenital anomalies are actually rare causes of these symptoms.

Trauma is, of course, an important cause of this type of pain. At the Clinic we believe that posterior protrusions of the intervertebral discs are traumatic in origin, and that in some cases they are probably the result of several injuries rather than of only one severe injury. It is important to recognize that the trauma may injure several structures in the lower region of the back and that removal of only one of the sources of the pain will not completely relieve the patient. In this regard, it is interesting to note that hypertrophy of the ligamenta flava has been found in 155 of the last 175 cases of posterior protrusions of intervertebral discs here reported. We believe that hypertrophy of the ligamenta flava in these cases was due to the trauma that produced protrusion of a disc. It is obvious to us that simple removal of the hypertrophied ligamenta flava in these cases will not completely relieve the patient; therefore, it is the duty of the surgeon to search carefully for a disc protrusion whenever hypertrophy of the ligamenta flava is found. Likewise, changes in the articular facets are sometimes encountered in cases of posterior protrusion of the intervertebral discs. Whether some of these facet changes are caused by the injuries that produced the protrusion of the disc or whether they are the result of the prolonged, faulty posture produced by both the injury and pain, cannot be stated now, but the point I wish to make is that the problem is complex, and that no one procedure is likely to be curative in all cases.

The rôle of tumors of the spinal cord and cauda equina in the production of this type of pain is well known. Similarly, metastatic tumors must always be thought of as causative factors. In this connection, I

should like to sound a note of warning. Tumors of the thoracic or even the cervical region of the spinal column may sometimes give rise to sciatic pain. As Dr. Camp has pointed out, a careful study of these regions with the aid of contrast media must be made before arriving at the conclusion that the patient has an intraspinal lesion in the lumbar region.

Explanation of the rôles of infection and postural defects in the production of pain in the lower part of the back and sciatic pain I must leave, for the most part, to the orthopedist. The condition called "sciatic neuritis," alone or as part of a multiple neuritis, is encountered occasionally; but it has been rare in my experience. Radiculitis of the cauda equina, which may be infectious in origin, has been similarly rare.

Whereas psychogenic factors certainly are not prominent in the causation of this type of pain, if indeed they may be said to cause it at all, in many cases they are important contributing factors. The physician who considers psychic factors unimportant and neglects to take them into account, will do so to his sorrow, particularly in some cases involving workmen's compensation. Surgical treatment is likely to have little effect on the pain, except to make it worse, of a patient afflicted with a traumatic neurosis, unless, of course, the patient has a definite intraspinal lesion. Interpretation of results is difficult because of the persistent complaints of this type of patient.

From the practical standpoint, what course should the physician take with the patient who visits him complaining of low back and sciatic pain? First, a careful history should be obtained, with special attention to the history of injury, to the type of the pain, whether the pain is recurrent or steady, and to the presence or absence of muscular weakness, atrophy, paresthesia, loss of sensation, and sphincteric difficulties. Second, it is important to determine whether or not the pain of which the patient complains is radicular in nature. The characteristics of radicular or "root" pain are as follows: the pain is usually sharp and it may be burning or gnawing, but it is rarely of an aching type.

The pain tends to follow a segmental or radicular distribution, but it may follow the course of the sciatic nerve or peroneal nerves. The pain often is aggravated by coughing, sneezing, straining, sharp flexion of the head on the chest. The pain tends to be worse at night; hence, a complaint of "night pain" always should bring to the physician's mind the possibility that the patient may have radicular pain. In very severe pain of this type the patient often finds that it is possible to obtain relief by walking, or by sleeping in a chair. It should be emphasized that it is not necessary that the pain possess all the above features to permit a diagnosis of root pain. In fact, it is somewhat rare to encounter all these features in one case, but enough symptoms will be present to render possible a diagnosis of pain of a radicular nature. The rather frequent association of radicular pain with paresthesia, reflex changes, muscular weakness or atrophy, sensory changes or loss of sphincteric control, also helps to identify it.

The examination of a patient complaining of low back and sciatic pain should be thorough and detailed. Careful medical examination, supplemented by appropriate laboratory studies, is indispensable and consultation with a urologist or gynecologist should be arranged if this appears necessary. Careful roentgenologic studies of the thoracic and lumbosacral regions of the spinal column and of the pelvis should be made. Orthopedic examination must not be omitted. Neurologic examination, with careful study of the tendon reflexes, of muscular strength, of muscular development to detect the presence of atrophy, of sensation—including pain, temperature, touch, vibratory and joint or position sense—and sphincteric tone, should be made. The posture of the patient should be noted, as well as the appearance of a list, or obliteration of the normal lumbar lordosis and limitation of motion and the production of pain with spinal movements.

The gait should be studied and any peculiarities noted.

The discovery that posterior protrusion of the intervertebral discs constitutes an important cause of low back and sciatic pain has forced physicians to revise many of their ideas on this subject. At the Mayo Clinic, a study has just been completed of 300 patients at operation on whom the existence of posterior protrusions of intervertebral discs was proved. Of approximately 10,000 cases of low back and sciatic pain encountered at the Clinic in the past three years, in only these 300 was it possible to arrive at a diagnosis of probable protruded intervertebral disc. The protrusions tended to occur at the regions of greatest curvature of the spinal column (Fig. 1), this appearing to be indirect evidence of the traumatic nature of the protrusions, since it is in these portions of the spinal column that mechanical stress is greatest in heavy lifting or pushing. However, there was a total of only 15 patients displaying protrusions in the cervical and thoracic regions of the spinal column, whereas there were 285 patients suffering from protrusions in the lumbar region. In 270 cases the protrusions were single, while in 30 cases multiple protrusions had occurred, two or more discs being definitely protruded. A total of 332 protrusions were found in the 300 cases. Of these, 30 had occurred at the third lumbar interspace, 140 at the fourth lumbar interspace, and 139 at the fifth lumbar interspace.

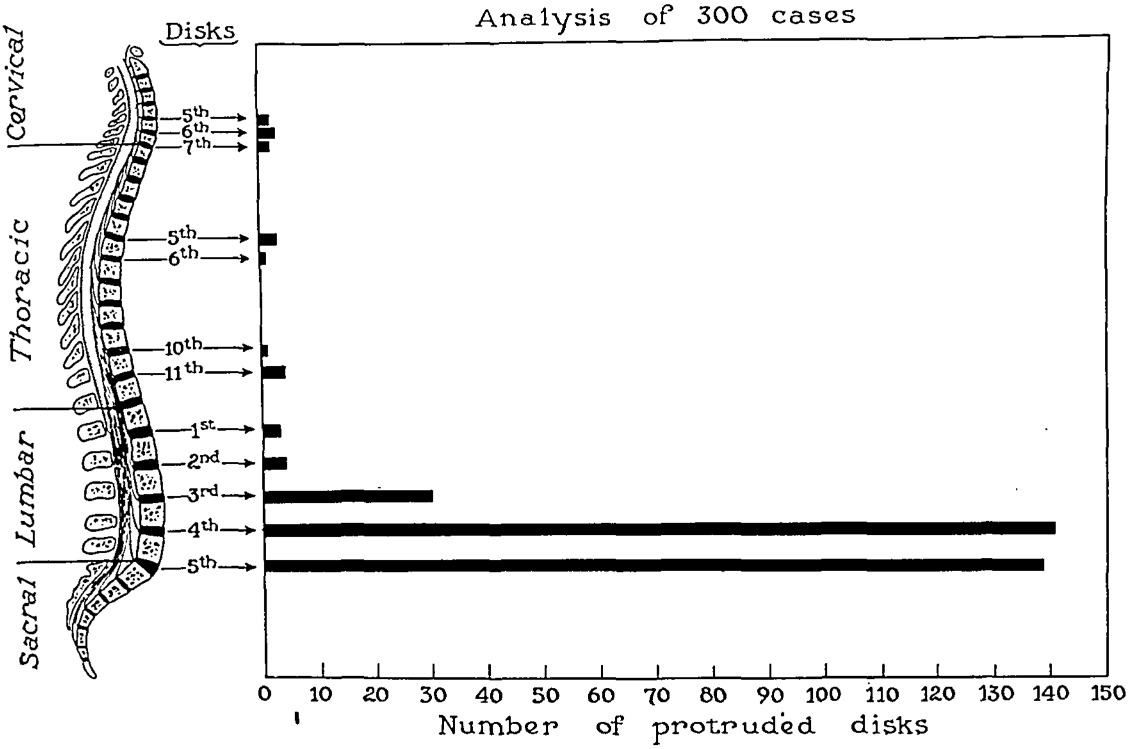

Fig. 1. Number and situation of protruded intervertebral discs in 300 cases.

There were 226 males among these patients and only 74 females; this difference of 152 probably is related to the greater liability of males to back injury. The average age at operation was 40 years. One hundred seventy-six patients (or approximately 60 per cent of cases) gave a history of injury; but in only 37 per cent of cases did the patient recall that the injury immediately preceded the onset of symptoms. One hundred twenty-four pa-

tients (41 per cent of cases) could recall no injury; but many of these patients were engaged in occupations requiring heavy physical labor accompanied by much back strain. The injuries usually occurred as a result of heavy lifting or pushing, or from falling, particularly while carrying a heavy weight on the shoulder.

The large number of patients (81 per cent of cases) reporting intermittence of symptoms is of great interest because intermittent symptoms constitute one of the most characteristic features of the syndrome. Whether, as Deucher and Love have recently suggested, this is due to intermittent edema of the protruded cartilage, or to withdrawal of the protruded portion into the body of the disc, or to slipping of the nerve away from its point of compression, cannot be stated definitely at this time.

Reference to Table I shows that unilateral sciatic pain was the most common type reported by all patients and that bilateral sciatic pain was reported in 15 per cent of cases. Extension other than sciatic was noted in only 3 per cent of cases, and in only 5 per cent was there no back pain. Accentuation of the pain at coughing, sneezing, straining, or flexing the head on the neck occurred in 53 per cent of cases, while nocturnal pain occurred in only 21 per cent. Paresthesia, usually in the lumbar fourth or fifth or sacral dermatomes, developed in 42 per cent of the cases of protrusion in the lumbar region.

Reference to Table I will show that the most important neurologic signs in cases of protruded intervertebral disc are Lasègue's sign, the presence of sciatic tenderness, and either diminution or absence of the Achilles tendon reflex. The hamstring reflexes may be either diminished or absent, and muscular weakness or atrophy or sensory loss may occur. In most cases, obliteration of the normal lumbar curve was noted, and movements of the back, particularly hyperextension, were limited and painful.

In the presence of positive neurologic findings, spinal puncture is indicated. This was done at the Clinic in 265 of the 285 cases in which protrusion was in the lumbar region. It was found that the only

TABLE I.—SYMPTOMS AND NEUROLOGIC SIGNS IN CASES OF PROTRUSION OF LUMBAR INTERVERTEBRAL DISCS: 285 CASES

	Cases	Per cent of 285
Unilateral sciatic pain	215	75
Bilateral sciatic pain	42	15
Nocturnal pain	61	21
Accentuation of pain on coughing, sneezing, etc.	151	53
Paresthesia	121	42
Sphincteric incontinence	14	5
Positive Lasègue's sign	231	81
Sciatic tenderness	172	60
Achilles tendon reflex diminished or absent	171	60
Hamstring reflex diminished or absent	51	18
Muscular paresis	63	22
Muscular atrophy	5	2
Sensory loss	62	22
Examination negative except for positive Lasègue's sign or sciatic tenderness	42	15
Examination objectively negative	17	6

chemical determination of value in cases of protrusion of a lumbar disc was estimation of the concentration of total protein in the spinal fluid. The manometer readings, Queckenstedt's test, the flocculation test for syphilis, Nonne-Apelt test, Lange's gold-sol test, and cell count were performed routinely on all spinal fluids; but they gave no information of value. In 174 cases (or 66 per cent) the concentration of total protein was 40 mg. or more per 100 c.c. of spinal fluid, while in 91 cases (34 per cent) the total protein of the spinal fluid was below 40 mg. Thus, examination of the spinal fluid is of definite assistance in the diagnosis of protruded intervertebral disc; but a spinal fluid that

appears to be normal does not exclude this condition.

Reference to Table I will show that in 42 cases (15 per cent) of cases of protrusion of lumbar discs, neurologic examination gave objectively negative results except for the finding of a positive Lasègue's sign or sciatic tenderness or both, while in 17 cases (6 per cent) neurologic examination gave completely negative results. The proper management of patients whose neurologic examination is negative is important. In all the aforementioned cases the history was suggestive because some of the features mentioned above were present. In most cases, the patients were placed on the combined orthopedic and neurologic service, and traction and physiotherapy, in addition to such other measures as were advised by the orthopedist, were tried. When no relief was obtained after instituting these measures, spinal puncture was performed. In many cases the spinal fluid was also normal. In a large number of these cases an epidural injection with performance of the reversed Queckenstedt test was done according to the technic of Love. If the patient sensed a reproduction of his former pain or if the reversed Queckenstedt test was positive, the patient was considered as having an intraspinal lesion and injection of contrast medium was carried out in order to localize the lesion.

Contrast media, usually radiopaque oil, were used to localize accurately the intraspinal lesion in most of the above cases. In 15 of the last 100 cases, however, it was felt so strongly that an intraspinal lesion was present in the lower lumbar region of the spinal column that laminectomy was carried out without the injection of a contrast medium. Since 96 per cent of the protrusions in the Clinic's 300 cases occurred in the third, fourth, or fifth lumbar space, the fourth and fifth having by far the largest numbers (84 per cent of all protrusions appeared in the fourth or fifth spaces), direct exploration by laminectomy in the lower lumbar region should be possible and the chances of finding the lesion ought to be good. A word of warning should be given, however: since lesions in the lower thoracic region of the spinal column may give a clinical picture similar to that of lesions involving the cauda equina, it will not usually be possible to dispense with the use of contrast media. In the rare cases in which the use of a contrast medium revealed no lesion (usually, it was found, because of the presence of a short *cul-de-sac*), a neurosurgeon and an orthopedist were both present at the laminectomy, so that spinal fusion could be effected at once if results of the exploration were negative.

Recently, attention has been called by Towne and Reichert and others to the production of pain in the lower part of the back and sciatic pain by hypertrophy of the ligamenta flava. In this respect, it is interesting to note that 155 of the last 175 patients here reported suffered hypertrophy of one or more of the ligamenta flava, in addition to protrusion of one or more intervertebral discs. In addition, we have observed 12 cases in which hypertrophy of the ligamenta flava alone was found at operation. Relief of pain followed operation in these cases.

The results achieved by removal of the protruded portion of the intervertebral disc have continued to be satisfactory. More than 90 per cent of the patients are relieved immediately and dramatically. It will, of course, require the passage of some years before it will be known how many are permanently relieved. Since several of these patients have suffered damage to other structures in the lower region of the back in addition to the intervertebral discs, it is not to be expected that relief in all cases will be complete. In one case, death was caused by contamination of the wound and bronchopneumonia; this produced a mortality of 0.33 per cent.

In conclusion I feel justified in saying that, although much remains to be learned, it is now possible to relieve more patients suffering from pain in the lower part of the back and sciatic pain than at any other period of medical history.

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SIGNIFICANT SKELETAL CHANGES IN LOW BACK AND SCIATIC PAIN: ROENTGENOLOGIC OBSERVATIONS[1]

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THE literature of the roentgenologic findings in low back and sciatic pain is voluminous. The region of the lumbar spine, sacrum, and sacro-iliac synchondroses is the site of many and diverse congenital anomalies. In addition, there are acquired changes produced by fractures, old or recent, arthritis, and other pathologic conditions. The relationship of these abnormal findings, whether they be of congenital or acquired origin, to the pain and discomfort suffered by the patient, has been much discussed and no final and definite conclusions have been reached by the various writers as to whether or not such a causal relationship exists. This question often arises in civil law suits and in cases of injury covered by workmen's compensation laws.

Low back pain is of very frequent occurrence and often forms a part of a symptom complex related to many of the different medical and surgical specialties. Steindler (1) divides it into two main types. The first includes those patients whose pain is referred from pathologic processes elsewhere than in the spine, such as the low back pain due to uterine displacement, the symptoms occurring in neurologic disorders and in numerous other diseases. The second group comprises those patients whose symptoms are due to regional disturbances of the lumbar spine, sacro-iliac synchondroses and the pelvis, or to structures immediately surrounding these skeletal areas. The roentgenologist is called upon to examine patients in both of these groups. No symposium on low back and sciatic pain would be complete without a description of the various changes encountered in these examinations. In this paper, the literature has been reviewed and the changes have been listed with an attempt to evaluate the rôle played by them in the production of low back and sciatic pain.

Certain congenital variations are so frequently encountered that the roentgenologist in making his routine report will often be tempted to give them no more than passing notice, inasmuch as their causal relationship to low back pain has not been proven. Included in this list are the following:

(1) Slightly bifid posterior spinous process of the fifth lumbar vertebra or the upper sacral segment.
(2) Lumbarization of the fifth lumbar vertebra, unilateral or bilateral.
(3) Sacralization of the fifth lumbar vertebra, unilateral or bilateral.
(4) Exaggerated or decreased lumbar lordosis.
(5) Scoliosis of the lumbar vertebræ, usually of mild degree, with or without actual rotation of the bodies of the vertebræ.
(6) Elongated transverse processes, often occurring with partial sacralization.
(7) "Butterfly" type of transverse process, fifth lumbar vertebra.
(8) Impingement of the transverse processes of the fifth lumbar vertebra on the iliac crests.

Wagner (2) reported different types of congenital defects of the lumbosacral joints with associated nerve symptoms some of which were of the above forms, and he felt his study confirmed the relationship between the symptoms and the changes which were demonstrated in the skeleton by roentgen examination. Hodges and Peck (3) studied the roentgenograms of 447 patients who presented symptoms of low back pain with radiation along either one or both of the sciatic nerves. In the control group studied, consisting of 538 individuals, 353

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had symptoms confined to the low back alone. They found the incidence of developmental anomalies more common in the first group, with sciatic radiation in a ratio of 2:1. Giles (4) found vertebral anomalies in 1,222 roentgenograms of the lumbar spine and sacrum. This number represented the negative genito-urinary examinations in a consecutive series of approximately 8,000 patients who were subjected to roentgen examination. Since these cases were sent to the x-ray department for genito-urinary examination only, the discovery of these anomalies was quite accidental and Giles concludes they had no bearing on the health of the individual and that their occurrence was probably of scientific value only. He suggests that they be called *normal variations* instead of *congenital* anomalies, and that individuals having these peculiarities of development are, in a fashion, just as normal as those having the standard or so-called normal pattern.

In the literature of the early years of the present century, references to the causation of low back and sciatic pain by impingement of one or both of the transverse processes of the fifth lumbar vertebra on the iliac crests can be found. However, the improvement of roentgenologic technic, due especially to the introduction of the stereoscope, proved that in many cases in which such impingement was apparently present, the diagnosis was erroneous. Of later years, practically no references are made to this condition as stereoscopic exposures have so frequently demonstrated that no real impingement exists.

In addition to the skeletal changes mentioned, others have been discussed in recent years which appear to have a more or less justifiable relationship to low back pain. No mention will be made of the roentgenologic findings in cases of herniation of the nucleus pulposus, which subject is covered by other members of this symposium.

Defects in the Neural Arch.—The defects in the neural arch have been described by Willis (7) under the term, "the separate neural arch"; by Ferguson (8), and by others as "pre-spondylolisthesis," and have more recently been the subject of a monograph by Glorieux and Roederer (9).

Fig. 1.

Fig. 2.

Fig. 1. Spina bifida. Small bony particle lying within the defect. Patient had no symptoms of low back pain.
Fig. 2. Pre-spondylolisthesis. Defect in lamina.

Willis states the separate neural arch is an anomaly peculiar to the lumbar vertebræ and may be found in any one of them and on either or both sides, but is usually confined to the pre-sacral. It is found more frequently when some other anomaly, such as a twenty-fifth pre-sacral, is present. The defects may be single or multiple. The rarest type is that found where the lamina joins the pedicle and is really a hiatus in the latter. Glorieux and Roederer believe that the case of this type reported by Hammerbeck (10) is the only one on record. More frequently the defects may be found in the mid-portion of the lamina, or they may be bilateral at about the same level in each lamina. The most frequent hiatus is that found in the middle of the posterior arch, which results in a failure of fusion of the posterior spinous process, producing the typical spina bifida. Another rare combination is the bilateral mid-laminal defect combined with the defective spinous process. Ferguson describes a separate ossification center for the spine of the first sacral vertebra which was present as a free piece of bone in the arch between the laminæ. This free piece may be united to the spine of the fifth lumbar vertebra by fibrous tissue or there may be a bony continuity of these parts. If this is present, it has the effect of prolonging the fifth lumbar spine downward between the sacral laminæ, an anomaly which this writer says may be painful if any motion of the fifth lumbar vertebra puts any pull or pressure on the laminæ of the first sacral segment. All writers are in agreement that the separate neural arch is a predisposing factor to spondylolisthesis, and the term, when no displacement is present, which is now most prevalent and accepted is "pre-spondylolisthesis."

Changes in the Articular Facets.—Ghormley (11) has drawn attention to the changes in the articular facets of the lumbar vertebræ as factors in the production of low back pain and especially pain with sciatic radiation. The facets form from one-fourth to one-third of the margin of the intervertebral foramina. Each of the articulations is composed of two articulating surfaces covered with hyaline cartilage and Ghormley feels that they must be regarded as true joints and as having a definitely perceptible amount of motion. He regards it as more reasonable to explain the pain, so often described, on a basis of actual injury to the joint rather than to explain it on a basis of ligamentous strain or injury. The facets have articular cartilage, and Ghormley compares the pain to that experienced in the locking of a joint due to a loose body, or in the case of the knee joint to a torn semilunar cartilage. The injury sets up muscle spasm which may last for several days, forcing the joint surfaces into contact and often perpetuating the pain until, either through manipulation, which may change the position of the joint surfaces sufficiently to relieve the irritation, or through gradual relaxation of the muscular spasm, relief may be obtained.

Ghormley and Kirklin (12) have described the technic for demonstrating these facets changes in the roentgenogram and the points to be observed, as suggested by them, are narrowing of the space between the articulating surfaces; marginal proliferation about the articulating facets indicative of hypertrophic changes; fractures through the surfaces of the facets or through the adjacent laminæ and pedicles, and increased radiability of the bony structures making up the facets and their supporting surfaces.

An unbiased opinion of the reports of Ghormley and Kirklin warrants the belief that no examination of the lumbar spine and sacro-iliac areas in cases of low back pain is complete without thorough examination of the facets, and changes in them cannot be ignored, certainly if no other etiologic evidence can be demonstrated.

Accessory Articular Processes in the Lumbar Spine.—Rendich and Westing (13), Nichols and Shiflett (14), and Farmer (15) have reported the occurrence of accessory articular processes in the lumbar spine. Litten has reported one case occurring in the superior articular process of the third lumbar vertebra. All other reported cases

occurred in the inferior processes of the second and third lumbar vertebræ. Farmer describes these supernumerary articular processes as varying on each side from 3 to 4 mm. to 1 × 1 × 1.5 cm. Sometimes they are triangular in shape. The sides are smooth and the density is that of cortical bone. This, together with the fact that there is no evidence of callus formation, differentiates them from fracture. Farmer noted too, that, when the condition was unilateral, the total length overall, including the accessory process, was greater than that of the corresponding process on the other side. If the accessory process was of large size, there was a depression in the articulation of the vertebra below to accommodate for it. Nichols and Shiflett believed that these processes were bony particles, anomalous epiphyses of the inferior articular processes.

However, Mensor (16) has reported cases in which the fragment of bone was irregular in outline and fracture lines ran in variable planes, depending upon the force producing the fracture. Varying amounts of displacement and rotation of the fragment were shown in his cases when they were studied by means of stereoscopic films. He found evidence of bone regeneration in patients who were followed over a given period of time and in many instances progression to complete healing occurred. He made a plea for the early recognition of these fractures and believed that they are of relatively frequent occurrence.

The roentgenologist must decide from the appearance of the bony particle in the film whether a congenital anomaly or a recent or old fracture is present. If the diagnosis is the latter, an opinion that a definite cause of the patient's low back pain exists, is justified.

The Narrow Lumbosacral Joint Space.—

Fig. 3.

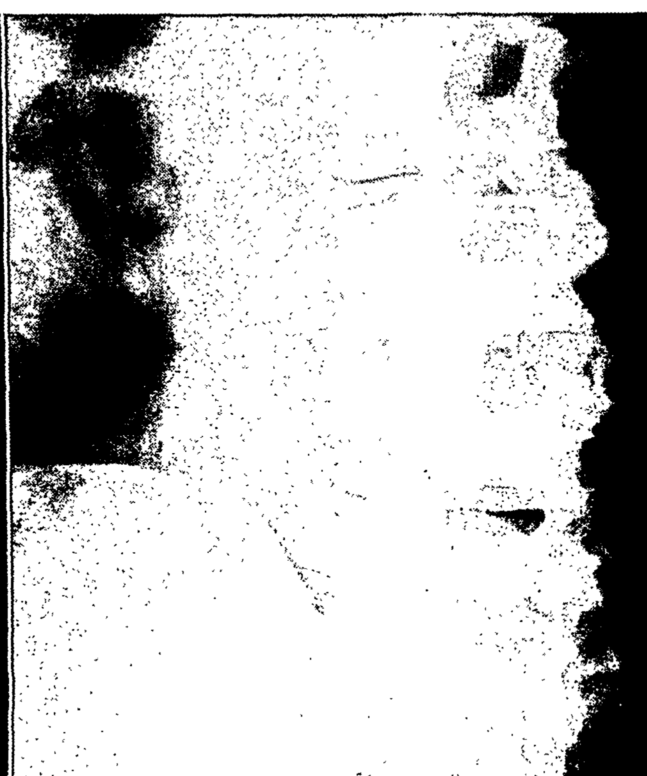

Fig. 4.

Fig. 3. Lateral projection. Pre-spondylolisthesis. The laminar defect is plainly visible.

Fig. 4. Changes in the articular facets: hypertrophic osteo-arthritis. Increased density of cortex of intervertebral facets, partial obliteration of interarticular spaces, second, third, and fourth lumbar vertebræ. Symptoms of low back pain with sciatic radiation.

Hodges and Peck found that a narrow lumbosacral joint space in the patients of their series was more common in those who had low back pain with radiation along the sciatic nerve than in those who had only low back pain or no symptoms, in the ratio of 4.5:1. Williams (17) has emphasized the relation of this symptom to the pain and believes that the decrease in the width of the space is due to degeneration of the nucleus pulposus. This may be caused by acute traumatic destruction of the lumbosacral disc or to a chronic traumatic destruction due to postural influences. He believes that infection and congestion of the disc play a secondary part and that the primary pathologic change is a mechanically altered lumbosacral articulation resulting, in most cases, from changes in the intervertebral disc. If the latter is subjected to too great a strain by trauma, herniation of the nucleus into the body of the vertebra may occur and complete collapse of the disc may later result. The joint space is decreased in width and the fifth lumbar vertebra may be subluxated slightly forward, backward, or to either side. Williams thinks the space is not completely obliterated at first, due to the interposed fibers of the annulus fibrosus. If motion of the joint continues, pressure atrophy occurs and the space is obliterated. Pain, Williams believes, is of the root pain variety and he advances two theories of its causation. The first is that changes in the vertebral foramina, producing constriction, may be sufficient to produce a compression of the fifth lumbar nerve as it emerges from the spinal canal. The second cause may be due to the intimate contact of the first sacral nerve posteriorly with the intervertebral disc and the contact of the fifth lumbar segment as it emerges from the canal with the lateral surface of the disc. If arthritic changes occur about the foramina, due to alterations in the intervertebral disc, irritation is set up in these segments and symptoms such as pain with sciatic radiation result. In the cases of acute traumatic destruction of the disc, the physiologic principle involved in recurrent attacks of pain is contraction of the sacro-spinalis muscles with the lumbosacral spine extended.

Badgley (20) believes that this theory of mechanical irritation of the nerve roots in the intervertebral foramina may be true in a certain group of cases but it is not true for the entire group comprised within the clinical entity of low back pain with sciatic radiation. The symptoms are not always necessarily due to direct or indirect irritation of the fourth or fifth nerve roots. This author feels that the pain is radiated primarily by a reflex mechanism from irritation to the sensory nerve endings in the soft tissues of the low back or from irritation to the capsular structures of the articular facets or intervertebral articulations. From these involved areas the pain is radiated centrally through the post-axial plexus of the lumbosacral joint to the post-axial surface of the lower extremity.

As Badgley's theory does not minimize the importance of the lumbosacral space, it is necessary that this finding be reported by the roentgenologist. His belief that localization of the causative factor of the syndrome cannot be confined to the lumbosacral space alone emphasizes the necessity of thorough examination of the entire lumbosacral area.

Posterior Luxations of the Lumbosacral Joint.—Johnson (21) and Smith (22) independently called attention to posterior displacement of the body of the fifth lumbar vertebra on the upper sacral segment. Both emphasized its relation to low back pain. Smith emphasized the necessity of obtaining a good lateral projection in the roentgenogram of the fifth lumbar vertebra as a slight shift of the tube would be sufficient to produce the appearance of a posterior displacement of the fifth lumbar when none actually exists, or, on the other hand, would obscure the displacement if it were actually present.

Willis (23), however, refuted these conclusions, basing his opinion on the study of 50 consecutive skeletons in the Hamann Museum. In only 17 did he find that the depth of the opposing surfaces of the lum-

bar and sacral articulation were equal. In the others, the depth of the two varied from one-sixteenth to four-sixteenths of an inch. In analyzing these surfaces, he showed that the differences in the antero-posterior depth was due to the conformation of the posterior borders of the sacral surfaces. In all cases the sacral diameters were the shorter. Because this supposed posterior displacement is found no more frequently in painful backs than in museum skeletons, he concluded it to be of no clinical importance, but, in reality, an optical illusion. Reynolds (24) in his editorial states that, as a result of Willis' study, posterior displacement of the fifth lumbar vertebra on the first sacral segment should not be included among the causes of low back and sciatic pain.

Platyspondyly.—Platyspondyly was described by Putti (27) and Lance (26) and later by Köhler (25). More recently Buchman (28) has reported 38 cases. He defines platyspondyly as a congenital anomaly consisting essentially of a widening of a vertebral body. Three types are recognized by the authors. Type 1 is characterized by a widened vertebra, diminished vertical diameter, and posterior spina bifida and is usually limited to the fourth and fifth lumbar segments. The adjacent intervertebral discs are increased in height. With this type, it is claimed, there are sometimes accompanying symptoms, such as weakness of the back and neurotrophic signs due to spina bifida. Köhler states that apart from widening of the body due to congenital causes, acquired broadening occurs, the cause of which is unknown. The breadth of the affected body is sometimes a third greater than that of the normal bodies. The density is increased in the roentgenogram; the discs are thickened. This condition, Putti states, predisposes the patient to symptoms usually known as lumbago.

Fig. 5.

Fig. 6.

Fig. 5. Large accessory articular process, second lumbar vertebra. Distinguished from fracture by smooth, rounded border. (Case of Paul A. Bishop, M.D.)
Fig. 6. Narrow lumbosacral space.

The second type occurs in the cervical and dorsal vertebræ and the third is a generalized form throughout the vertebræ and so does not come within the scope of this discussion. Since this change has not been found in museum skeletons and in roentgenograms of normal individuals without low back and sciatic pain in sufficient numbers to disprove its relationship to the syndrome, its presence must be regarded as a possible cause of such symptoms.

In conclusion, the study of these various changes encountered in the roentgenologic examinations of patients complaining of low back and sciatic pain, emphasizes the fact that roentgenologic examination is mandatory, no matter how thorough or complete the clinical examination may be. It is impossible to prove from roentgenograms alone that skeletal changes are the cause of symptoms. Such practice would lead to grave errors in treatment and to possible injustice to patients. Rational therapy can be undertaken only after the most comprehensive clinical and roentgenologic studies.

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AIR MYELOGRAPHY IN THE DIAGNOSIS OF INTRASPINAL LESIONS PRODUCING LOW BACK AND SCIATIC PAIN[1]

By W. EDWARD CHAMBERLAIN, M.D., *and* BARTON R. YOUNG, M.D., *Philadelphia*

From the Department of Radiology, Temple University Medical School and Hospital, Philadelphia

VISUALIZATION of the spinal canal by the use of air as a contrast medium was suggested by Dandy (1), in 1918, but until recent years the necessary combination of good detail and adequate contrast in roentgenograms was not available. In 1934, Coggeshall and von Storch (2) showed that the lumbo-caudal sac could be visualized by air but their report was limited to the findings in three normal patients. The same year Van Wageneen (3) reported three cases of complete spinal block in which the lower level of the lesion was visualized by injection of small amounts of air. Our use of air was prompted by our desire to find a substitute for lipiodol because of the possible harmful effects of lipiodol on nervous tissue and the necessity of laminectomy for its removal. Gaseous contrast media, such as air or oxygen, are readily absorbed and, therefore, spinal canal visualization need not be restricted to patients whose symptoms and neurologic findings are clear-cut.[2] This means that a contrast medium will be used more often and a greater number of patients with low back pain will have the benefit of this procedure if air is used instead of lipiodol.

We have used air myelography routinely for the past three years in all patients who have had symptoms and sufficient neurologic findings to make us suspect an intraspinal lesion. The method is applicable for a lesion at any level in the spine but is especially valuable to demonstrate the lumbo-caudal sac. The lumbo-caudal sac should be examined in any patient with persistent sciatic pain who exhibits abnormalities in the Achilles reflex, in sensation especially to heat or cold over the dorsum of the foot, or impairment of muscle power in the foot. Our experience is based on the findings in over 150 cases of myelography, and in more than half of this number the lumbo-caudal sac was studied. Ten of the group of patients who had positive findings in this region after air injection came to operation and in each case the uncovered lesion was at the exact level demonstrated by the roentgenograms. The method is not misleading as we have not had any cases in which the myelograms indicated a lesion without finding it at operation. Of the ten cases operated on, herniated disc was uncovered in four, neoplasm in three, hypertrophied ligamentum flavum in two, and arachnoiditis with hour-glass constriction in one.

The diagnosis of an intraspinal tumor or space-taking lesion depends upon the indentation of, or the encroachment upon, the limiting membrane of the lumbo-caudal sac. The boundaries of the subarachnoid space are sharply delineated by air so that any change of configuration of the margins can be visualized by roentgenograms. A herniated cartilaginous disc carries the posterior longitudinal ligament dorsad so that an indentation of the ventral aspect of the air column is produced (Fig. 2). Usually this is more apparent by the lateral roentgenograms but in several instances we have noted the defect exclusively on the anteroposterior projections. If seen on this latter view, it may be unilateral or bilateral (Figs. 3 and 4). Thickening of the ligamentum flavum is manifested on either the lateral or posterior aspect of the air column. In our two cases which were operated on, the defect was better seen on the anteroposterior

[1] Presented before the Twenty-fourth Annual Meeting of the Radiological Society of North America, at Pittsburgh, Nov. 28–Dec. 2, 1938.

[2] We have used oxygen routinely for over a year because it is absorbed faster than air and produces less reaction.

Fig. 1. Normal lumbo-caudal sac. (*Upper*) Sharp definition of lateral margins as seen on anteroposterior projection. (*Lower*) Arrow indicates normal indentation of posterior longitudinal ligament seen at levels of intervertebral discs in lumbar region.

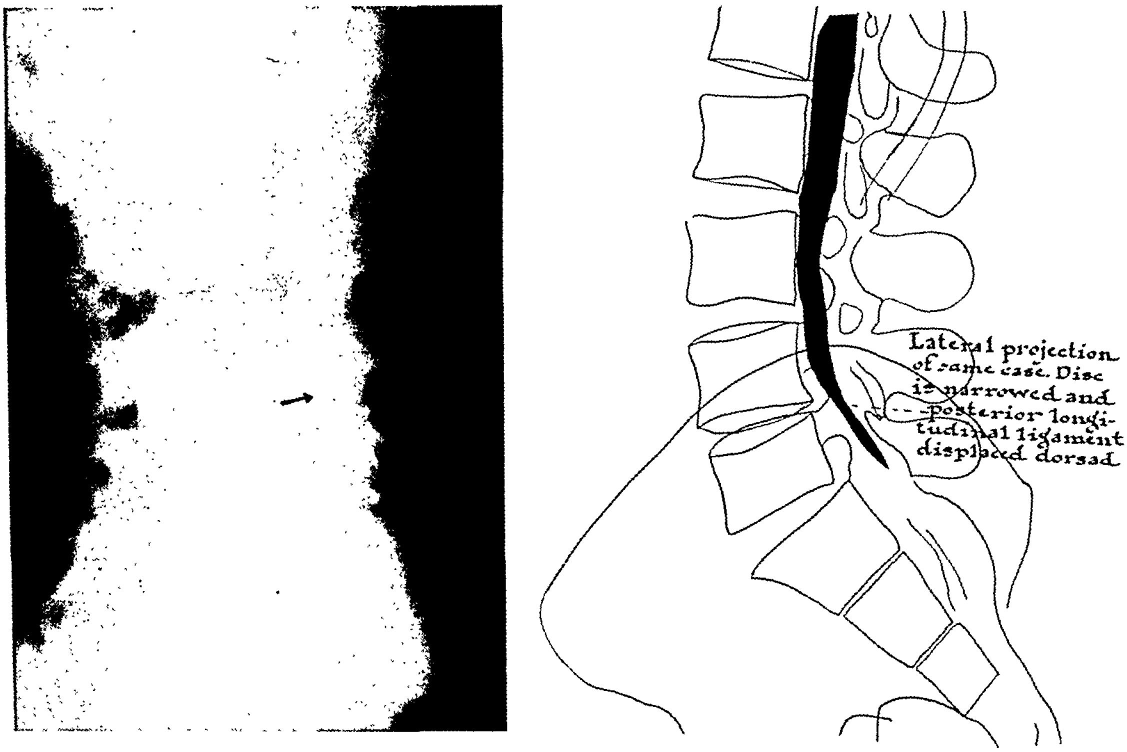


Fig. 2. Dorsal displacement of posterior longitudinal ligament by herniated disc at 4-L interspace. Note narrowing of interspace. At operation the sac below the protruded disc was almost obliterated by resultant arachnoiditis. The narrowing below level of protruded disc is due to arachnoidal adhesions.

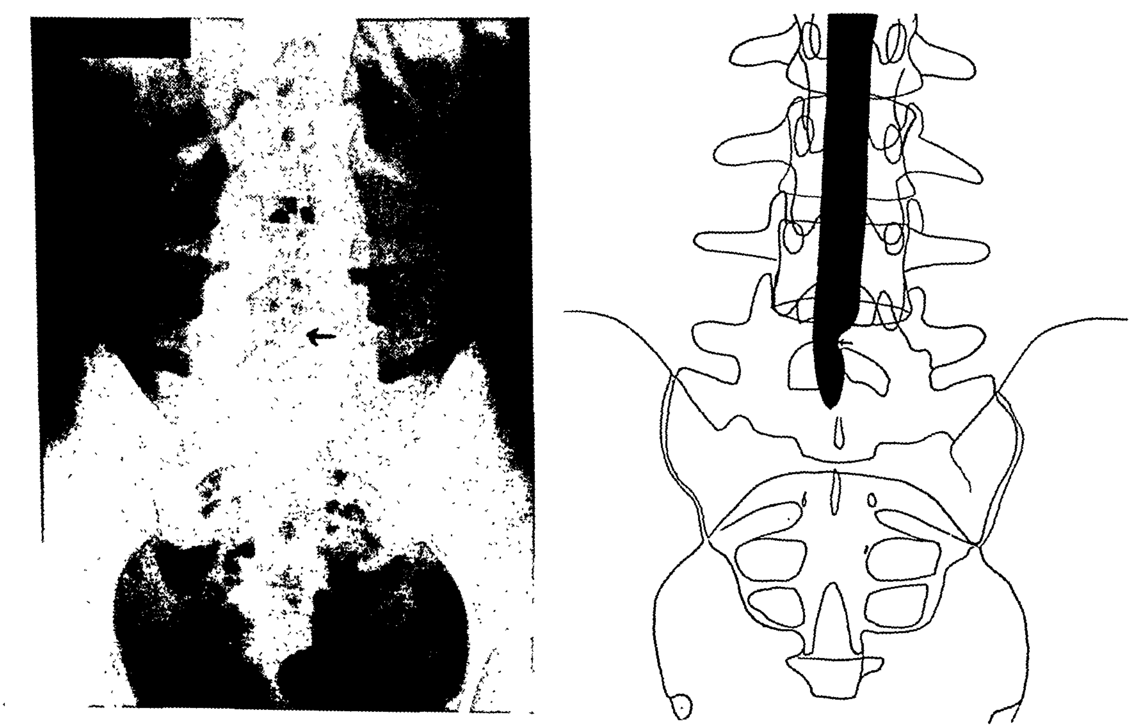


Fig. 3. Unilateral defect of air column due to cartilaginous disc herniation verified by laminectomy. A similar defect may be produced by a hypertrophied ligamentum flavum (see Fig. 5).

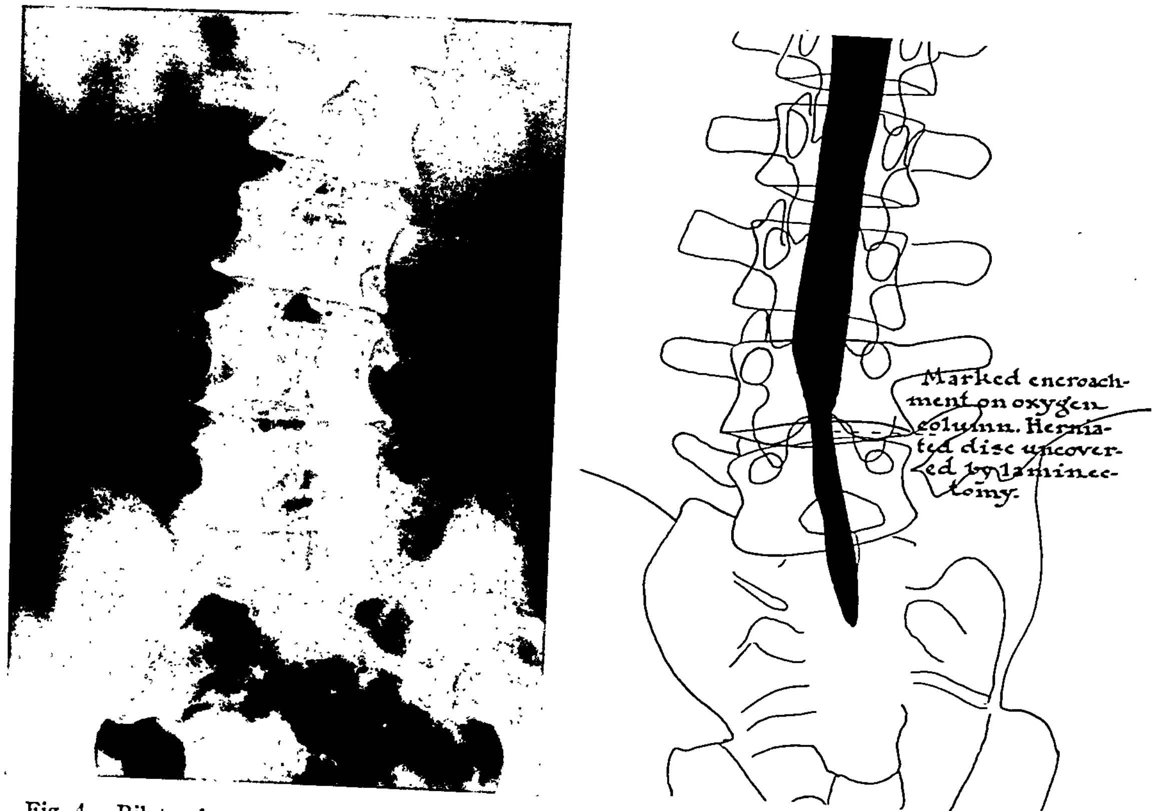


Fig. 4. Bilateral constriction defect of subarachnoid space in patient with "sciatic neuritis." At operation a herniated disc was uncovered. Compare distance, indicated by dots, between lateral margins of sac at involved level with normal width of sac one interspace above.

Fig. 5. Indentation of lateral margin of lumbo-caudal sac due to thickened ligamentum flavum. If lateral projection does not also reveal the shadow, it is impossible to differentiate from herniated disc.

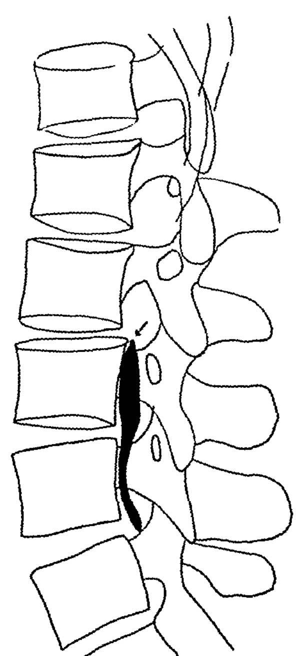
films (Fig. 5). As would be expected, a tumor frequently completely occludes the subarachnoid space, and, therefore, causes a complete block. Queckenstedt test may disclose this fact but a small quantity of air—4 to 6 c.c.—should be injected anyway to show the undersurface of the tumor (Fig. 6).

Our technic (4, 5) is as follows: In cases in which Queckenstedt shows either complete or partial block, the patient is placed in the upright sitting posture with back against the Potter-Bucky diaphragm immediately after the injection of from 4 to 6 c.c. of air. The site of injection is below the suspected level of the lesion. Stereoscopic anteroposterior projections are obtained before the patient is turned for the stereoscopic lateral films. No difficulty is ever encountered in localizing the inferior aspect of a tumor or herniated disc which is completely blocking the canal, and, in our opinion, the use of lipiodol is never justified in such a case. We have demonstrated complete block in the lumbocaudal sac in three patients with severe

A

Fig. 6. Complete block of spinal canal by ependymoma. (*A*) Diagnosis of intraspinal neoplasm made before air injection because of widened interpediculate spaces of first and second lumbar segments (dots mark mesial edges of pedicles).

B



C

Fig. 6. Complete block of spinal canal by ependymoma. (*B*) Arrow indicates top of air column trapped below tumor; (*C*) Tracing of lateral roentgenogram.

and persistent low back pain. Two of these had tumors, while in the other a herniated cartilaginous disc was found.

Provided there is no block by Queckenstedt, the entire lumbo-caudal sac must be visualized. This is done by placing the patient on the side in Trendelenburg position at an angle of from 30 to 35°. An 18- or 20-gauge needle is inserted into the subarachnoid space at the second lumbar interspace and spinal fluid is exchanged for air in 5 c.c. volumes until air returns from the needle. It usually takes from 30 to 50 c.c. of air to fill the canal in adults, depending upon size. The needle is then withdrawn and the patient moved onto an ordinary horizontal x-ray table with Potter-Bucky diaphragm, the table being elevated at one end by blocks in order to maintain the Trendelenburg position. It is important to keep the patient's head lower than the rest of the body or air will ascend into the cranium. The resultant loss of air content from the spinal canal may interfere with the success of the myelographic procedure, and the patient invariably suffers more or less severe headache when this happens.

Stereoscopic lateral and anteroposterior projections with the patient in the usual conventional positions (except for the necessary Trendelenburg) are probably sufficient in most cases. Because we have been especially interested in visualizing the effects of hyperflexion and hyperextension of the spine upon the configuration of the ventral limiting membrane, we have made it a routine practice to make stereoscopic lateral projections in these special additional postures.

When we began this work we supposed that only patients exhibiting signs of progressive lesions would merit myelographic study. Recently, however, we have obtained positive findings by air myelography in patients with intermittent episodes of low back pain and we are now engaged in an effort to determine whether lesions such as herniated intervertebral discs may not be influenced by hyperflexion and hyperextension of the spine.

SUMMARY

We feel that air myelography is a harmless yet reliable method of visualizing tumors or space-taking lesions in the spinal canal. It is especially valuable to demonstrate intraspinal lesions which cause low back pain because the limiting membrane of the lumbo-caudal sac is sharply demarcated by the air. Since air or oxygen is harmless and readily absorbed, either can be used not only in patients with definite symptoms but also in the so-called borderline cases. The cause for low back pain will be discovered more frequently if the contrast medium be air rather than lipiodol, since there is less hesitation about the injection of air and, therefore, more patients will have the benefit of the procedure. More than half of our series of 150 cases of air myelography had lumbo-caudal sac visualization. Ten of the group who had positive findings in the lumbo-caudal sac came to operation. The accuracy of the method is emphasized by the finding of the lesion at the exact level demonstrated by the roentgenograms in all of these ten cases operated upon. The roentgenologic appearance of the various intraspinal lesions which cause low back or sciatic pain has been presented.

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INTRASPINAL LESIONS ASSOCIATED WITH LOW BACK PAIN AND SCIATIC PAIN, AND THEIR LOCALIZATION BY MEANS OF LIPIODOL WITHIN THE SUBARACHNOID SPACE[1]

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THE use of lipiodol for the roentgenologic visualization of space-occupying lesions within the spinal canal was introduced by Sicard and Forestier (1), in 1922. A short time before, Dandy (2), in 1919, had suggested the injection of air into the spinal subarachnoid space as a means of localizing obstructing lesions but because of certain difficulties attending the use of air he soon gave it up in favor of lipiodol. From the time of its origin until the present decade, lipiodol was thought to be useful only in the presence of obstructing lesions and for the demonstration of such was used in amounts varying from 0.5 to 2 c.c. Neurosurgery and knowledge concerning tumors of the spinal cord were developing fast in that time and it was soon apparent that in the interests of better results, some means of localizing the lesion before obstruction and irreparable damage to the cord had occurred, was needed. One of us (Camp, 3) felt that if enough lipiodol to visualize the subarachnoid space completely at any desired level was used, then small, non-obstructing lesions would become visible by virtue of their space-occupying properties and the resultant filling defect. With this end in view, about 1930, we began to use 5 c.c. of lipiodol for this work because it was found from previous experience with smaller amounts to be the optimum volume for the most accurate and consistent localization of non-obstructing lesions. Some lesions could have been shown with smaller amounts, but, on the other hand, a number of surprisingly large tumors and particularly multiple lesions would have been easily overlooked with amounts less than 5 c.c.

That lipiodol is an irritant to the spinal meninges has been fully admitted by early and recent observers. At the Mayo Clinic we have frequently warned against its indiscriminate use and emphasized that it is contra-indicated in frank inflammatory lesions (4, 5, 6, 7). Nevertheless, the consensus of experienced neurologists and neurosurgeons is that, when used judiciously and in selected cases, the advantages of its use far outweigh any disadvantages that have been recognized. Our experience to date with its use in the recognition of space-occupying lesions affecting the spinal cord and cauda equina indicates that this procedure has attained a degree of accuracy that is equaled by few other diagnostic roentgenologic methods.

Within the last two years there has been a tendency to revive the use of air as a contrast agent for the localization of lesions within the spinal canal and the statement has been made that the use of lipiodol in obstructing lesions and in lesions affecting the cauda equina is unjustifiable (8). There is no doubt that air injections will reveal certain lesions affecting the spinal cord and cauda equina and undoubtedly this procedure should be used more frequently before resort is had to lipiodol. Our experience to date, however, with both methods in the case of lesions involving the lumbar portion of the spinal canal, indicates that lipiodol is more accurate, that it will reveal certain structures not seen with air, and that it has localized lesions that air has failed to disclose. Because of the obvious difficulty in controlling the position of air in the cervical and thoracic regions, there is no comparison in the efficiency of the two methods when these regions are involved, except, perhaps, in the case of a completely obstructing lesion.

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[1] Read at the Annual Meeting of the Radiological Society of North America, at Pittsburgh, Nov. 28–Dec. 2, 1938.

The observations recorded in this paper are based on 417 cases in which lipiodol was injected into the spinal subarachnoid space for the purpose of localizing a suspected lesion affecting the spinal cord or cauda equina. In 283 of the cases (67.9 per cent), subsequent laminectomy was performed. All of these patients were examined between Jan. 1, 1936, and July 1, 1938, inclusive, a time interval that was purposely selected in order that it might reflect the effect of our recent knowledge concerning protruded intervertebral discs on the selection of patients for study with lipiodol. That clinicians and neurologists have become more conscious of protruded intervertebral disc is reflected in the fact that in the six years directly preceding January, 1936, only 108 lipiodol studies were made at the Mayo Clinic and the procedure was used in 37 per cent of all lesions of the spinal cord operated upon. At the present time, lipiodol is used in about two-thirds of all lesions of the spinal cord operated upon. In this series low back pain or sciatic pain was present in 70 per cent of the patients referred for lipiodol study. In 126 cases (30 per cent) the lipiodol findings were negative. The positive lipiodol diagnoses can be grouped as follows: cord tumor, 45; protruded intervertebral disc, 208; hypertrophied ligamentum flavum without disc protrusion, six, and miscellaneous, 32.

TECHNIC OF EXAMINATION

Five cubic centimeters of lipiodol (heavy) were injected *via* the lumbar route in all cases. The technic for the fluoroscopic and radiographic examinations is the same as that described in earlier papers (3, 5, 6, 7) and will not be discussed in detail here. Suffice to say that a tilting fluoroscopic table with appropriate foot and shoulder rests is necessary for the examination. We have recently devised, with the co-operation of one of the manufacturers, a new table which, while the same height as standard tables, will tilt 90 degrees in either direction. This will greatly facilitate the examination and permit a complete study to be carried out in about half the time formerly required. Some method of quickly recording the fluoroscopic image on films is highly desirable. If a "spot" film device is not available, excellent films may be made by sliding a cassette under the fluoroscopic screen, delimiting the area by the fluoroscopic shutters, and changing from fluoroscopic to radiographic technic by means of a quick change-over switch on the control panel. In addition to localized "spot" films of the lesion, a large film revealing several contiguous vertebræ is necessary in order to establish the anatomic level accurately. This is extremely important when surgical intervention is contemplated because congenital variations at the lumbosacral junction or the presence of additional lumbar vertebræ may easily mislead the neurosurgeon when he counts the spinous processes for determining the site of laminectomy. It is necessary that the surgeon and roentgenologist agree on the anatomic level of the lesion before operation as otherwise small lesions may be overlooked when the laminectomy is small.

ANALYSIS OF CASES

Tumor of the Spinal Cord.—A diagnosis of tumor of the spinal cord was made by lipiodol studies in 45 cases and in 26 instances the patient had complained of low back pain or sciatic pain. Forty-three of the patients were operated on. In two cases no lesion to account for the lipiodol deformity was found (error of commission). In four instances a lesion other than tumor was found (error of interpretation). These consisted of two cases of protruded intervertebral disc, one case of old hemorrhage associated with meningeal adhesions, and one case in which the cord was angulated and distorted by a marked kyphosis of the spine. In the 43 cases of cord tumor operated upon, the exact location of the tumor as to whether it was extradural, intradural, or intramedullary was stated by the roentgenologist in 35 cases, and this was confirmed in 33 instances. In the eight remaining cases the lipiodol de-

Fig. 1. Protruded lumbosacral intervertebral disc. Typical unilateral deformity of lipiodol shadow.

formity produced by the tumor was such that it was impossible to state the relation to the dura or cord. While this may seem of academic interest, it is of no little importance in considering the advisability of surgical intervention, particularly in intramedullary lesions, in which the prognosis is generally poor regardless of the type of treatment. The value of lipiodol in revealing multiple lesions has been discussed in a previous publication (5). Two such cases were encountered in this series, both subdural tumors coexistent with protruded intervertebral discs. One does not usually associate low back pain and sciatic pain with tumors in the cervical portion of the spinal cord. Such a combination was present, however, in 31.8 per cent of tumors of the cervical portion of the spinal cord occurring in a series of 100 consecutive tumors. In the same series low back pain or sciatic pain occurred in 50 per cent of the tumors in the thoracic region of the spinal cord and in 83 per cent of the tumors in the lumbar region. Such a distribution of the lesions emphasizes that it is not sufficient to examine only the lumbar portion of the spinal canal even though low back pain or sciatic pain may be the presenting symptom.

Protruded Intervertebral Disc.—A diagnosis of protruded intervertebral disc was made by lipiodol studies in 208 cases and 203 of these patients underwent laminectomy. In 194 cases the diagnosis was confirmed by the surgeon. In one case no lesion was found to account for the lipiodol deformity (error of commission). In eight instances a lesion other than a protruded disc was found by the surgeon (error of interpretation) and they are listed as follows: chronic arachnoiditis with contraction of the dura, one; fracture of the twelfth thoracic facet, one; vascular tumor, varices, and so forth, four; hypertrophied ligamentum flavum, one, and neurofibroma, one.

The usual deformity produced by a protruded intervertebral disc is a unilateral extradural type of indentation of the lipiodol shadow occurring opposite an intervertebral disc (Fig. 1), and such a deformity occurred in 127, or 65.5 per cent, of the disc cases. In 67 cases (34.5 per cent) the deformity was bilateral (Fig. 2). In 141 cases (72.7 per cent), a deformity was visible in the lateral lipiodol films. In about 50 per cent of cases the deformity was not visible in the supine position. Partial obstruction of the lipiodol was observed in 22 cases (11.3 per cent) and complete obstruction in five cases (2.6 per cent).

In addition to the deformity of the lipiodol shadow produced by the disc itself, the defect is often augmented by associated edema or displacement of contiguous nerve roots or by pressure from hypertrophy of the ligamentum flavum, at the same level. Evidence of such additional changes may be very helpful in substantiating the diagnosis of a protruded disc when the deformity of the protrusion itself is not great. Enlargement of a nerve root shadow indicating edema of the nerve was visible in 33 cases, or 16.8 per cent (Fig. 3), and displacement of the nerve root shadows was observed in 63 cases (32.1 per cent).

Protrusion of two or more intervertebral discs was reported in 27 patients, or 12.9 per cent of all the cases in which a protrusion was diagnosed by lipiodol (Fig. 4). The distribution of the multiple protrusions as diagnosed by lipiodol is shown in Table I. The protrusion involved two discs in all but three cases.

Twenty-four of these patients were operated upon and only one protruded disc was found in three instances. In two other cases in which two protrusions had been diagnosed only one protrusion was

Fig. 2. Fig. 3.

Fig. 2. Protruded intervertebral disc between fourth and fifth lumbar vertebræ. Bilateral deformity of lipiodol shadow.

Fig. 3. Protruded intervertebral disc between third and fourth lumbar vertebræ. Unilateral deformity of lipiodol shadow. Arrows point to enlargement of contiguous nerve root shadows, indicating edema of these nerves secondary to pressure from protruded disc.

found but a hypertrophied ligamentum flavum was found at the level where the second protrusion had been reported. In two cases, protrusion of the fourth and fifth lumbar discs was found at operation when protrusion of only the fourth had been reported from the lipiodol studies. In each instance, however, the caudad movement of the lipiodol was completely obstructed by the protrusion between the fourth and fifth lumbar vertebræ and, as a result, the second protrusion between the fifth lumbar vertebra and the sacrum could not be visualized.

Hypertrophy of the Ligamentum Flavum.—This condition has frequently been found by neurosurgeons in conjunction with a protruded intervertebral disc. It usually occurs at the same level as the protrusion, but may occasionally be found at other interspaces. Localized hypertrophy of the ligamentum flavum without coincident protrusion of the disc is not common. Because of the anatomic localization of the

TABLE I.—DISTRIBUTION OF MULTIPLE PROTRUSIONS OF INTERVERTEBRAL DISCS AS DIAGNOSED BY LIPIODOL

Affected Discs	No. Cases
L5[1] and L4	6 (22.2%)
L4 and L3	14 (51.9%)
L3 and L2	1
L1 and T12	1
T12 and T11	1
T11 and L5	1
L3, L4 and L5	1
L2, L3 and L4	1
T11 to L5 and subdural tumor T10	1
Total	27

[1] In this paper each intervertebral disc is given the same name as the vertebra immediately cephalad to it.

ligamentum flavum, this structure, when it hypertrophies, will compress the lipiodol column posteriorly and laterally. Hypertrophy of the ligamentum flavum when it occurs without associated protrusion of an intervertebral disc is characterized in the lateral view by a broad or rounded indentation on the posterior aspect of the lipiodol column between contiguous laminæ (Fig. 5-*a*). In the prone or in the supine position, the hypertrophy may be portrayed by a unilateral but generally by a bilateral broad indentation of the lipiodol column (Fig. 5-*b*). In many instances the deformity is so augmented by pressure from an associated protrusion of the disc that the diagnosis of hypertrophy of the ligamentum flavum may not be possible unless a deformity of the lipiodol shadow posteriorly can be demonstrated (Fig. 6). A diagnosis of protruded intervertebral disc and associated hypertrophy of the ligamentum flavum was made from the lipiodol findings in 29 cases. All of these diagnoses were confirmed at operation. In six cases a diagnosis of hypertrophy of the ligamentum flavum without associated protrusion of the disc was made from the lipiodol examination. Five of these patients were operated upon and in

TABLE II.—MISCELLANEOUS LIPIODOL DIAGNOSES AND FINDINGS AT OPERATION

Lipiodol Diagnosis	No. Cases	Findings at Operation	No. Cases
Lesion producing complete obstruction	6	Protruded intervertebral disc	6
Lipiodol in epidural space, indeterminate	4	Protruded intervertebral disc	4
Indeterminate	2	Protruded intervertebral disc Inflammatory lesion	1 1
Posterior defect lesion not specified	1	Hypertrophied ligamentum flavum	1
Inflammatory lesion	2	Inflammatory lesion	2
Lesion producing partial obstruction	4	Neurofibroma Vascular lesion	1 3
Total	19		19

Fig. 4. Multiple protruded intervertebral discs. Typical deformity of lipiodol shadow caused by protrusion of the intervertebral discs between the third and fourth, and between the fourth and fifth, lumbar vertebræ.

each instance the roentgenologic diagnosis was confirmed.

Miscellaneous Roentgenologic Diagnoses.—The reports of 32 cases are classified in this group. They include such diagnoses as indeterminate, lipiodol in epidural space, obstructing lesion, inflammatory lesion, and so forth. Nineteen of these patients were operated upon and the lipiodol diagnosis and findings at operation are shown in Table II.

Negative Lipiodol Findings.—The lipiodol examination was reported as negative in 126 cases, or 30 per cent of all cases examined. Sixty-three patients in this group complained of low back pain or sciatic pain. Thirteen patients were operated upon in spite of the negative lipiodol study. The operation revealed no lesion in two cases, a protruded intervertebral disc in seven cases, and hypertrophy of the ligamentum flavum in four cases. It is interesting that in this group the protruded intervertebral discs associated with negative lipiodol findings were all located at the lumbosacral junction. Anatomically there is a very good reason for this error because at the lumbosacral junction the spinal canal is relatively large and the diameter of the caudal sac may be small because of its fusiform termination. Under such circumstances, even a large protruded disc may exist without indenting the caudal sac. Two anomalies of the *cul-de-sac,* which occurred in 5.7 per cent of all our disc cases, explain the inability of the radiologist to visualize certain protrusions of the lumbosacral disc regardless of the contrast agent used in the subarachnoid space. In the first of these anomalies, the *cul-de-sac* terminates at the ordinary site but is considerably narrower than usual below the level of the fourth lumbar disc (Fig. 7). In the second, the *cul-de-sac* terminates one or two segments higher than usual, occasionally above the lumbosacral junction, with or without variation in its usual diameter (Fig. 8). It is obvious that in the presence of either anomaly a protruded lumbosacral intervertebral disc may not be disclosed by lipiodol or any other contrast agent. This situation prevailed in five of the seven protruded intervertebral discs that were

found at operation when the lipiodol study had been reported as negative. We have included these cases as errors of omission but because the anatomic anomaly prevented the visualization of the lesion, it is doubtful whether they should be considered as such. Now, when such a condition is present and the lipiodol examination is negative, we report that the examination is negative but that, because of the anomaly in the termination of the *cul-de-sac*, a lumbosacral protrusion could be present without deforming the lipiodol. This, we feel, is important, because if the history and physical findings in a case indicate protrusion of a disc and the above situation prevails, an exploratory laminectomy over the lumbosacral interspace may be advisable.

Accuracy of Lipiodol Examination.—The details of the errors occurring in this group of 417 lipiodol studies are shown in Table III. The errors have been grouped as two kinds, errors of interpretation and errors of commission or omission. Errors of interpretation are those in which the examiner miscalled the type of lesion found at operation and these are discussed in detail under the appropriate diagnosis. An organic lesion was found in all such cases at the site of the lipiodol deformity and, therefore, this error cannot be charged to the method but should be charged to the examiner. It amounted to 6 per cent for the entire series. Errors of omission or commission are cases in which the lipiodol diagnosis was entirely incorrect: either a lesion was diagnosed as a result of the roentgenologic examination and none was found at operation, or the roentgenologic examination was reported as negative and a lesion was found at operation. This error amounted to 4.9 per cent for the entire group. If the five cases with an anomaly of the *cul-de-sac* and a protruded intervertebral disc are removed from this

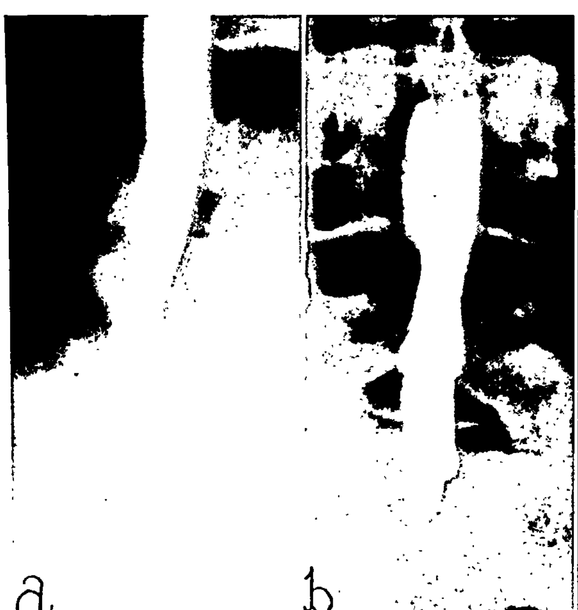

Fig. 5.

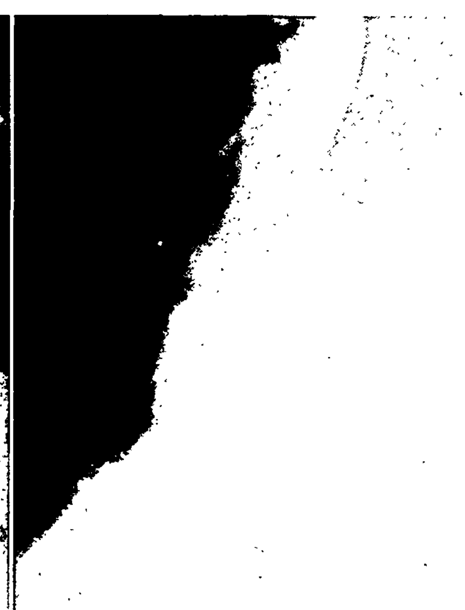

Fig. 6.

Fig. 5. Hypertrophy of the ligamentum flavum without associated protrusion of the intervertebral disc. (*a*) Lateral position, revealing broad indentation of posterior aspect of lipiodol shadow which is typical of hypertrophy of the ligamentum flavum. (*b*) Prone position, revealing broad bilateral narrowing of lipiodol shadow opposite intervertebral space between fourth and fifth lumbar vertebræ. The deformity is more marked on the left side.

Fig. 6. Protrusion of the intervertebral disc between the fourth and fifth lumbar vertebræ, with associated hypertrophy of the ligamentum flavum. Lateral position revealing indentation of lipiodol shadow, anteriorly, due to protruded intervertebral disc and indentation of lipiodol shadow, posteriorly, by hypertrophied ligamentum flavum.

group, and they probably should be since the method could not hope to reveal the lesion, this error would be reduced to 3.2 per cent. In other words, lipiodol in the subarachnoid space had localized the lesion with an accuracy of 96.8 per cent and had identified the character of the lesion with an accuracy of 90.8 per cent.

Reactions to Lipiodol.—It is difficult to appraise accurately the amount of reaction, if any, that a patient may have following the injection of lipiodol into the subarachnoid space. In most instances the examination is antedated by recent lumbar puncture and under such circumstances it is hard to say which symptoms are due to one procedure and which to the other. In the great majority of cases in which a positive diagnosis was made, operation was carried out immediately following the examination or so soon afterward that it became impossible to judge symptoms because of the interjected surgical procedure. From our experience with lipiodol over many years, it is our opinion that the reaction following the use of 5 c.c. is no greater than that occasioned by the use of 2 c.c. and, because 5 c.c. will reveal lesions more accurately than 2 c.c. or less, we believe it is the quantity of choice.

Fig. 7 Fig. 8.

Fig. 7. Anteroposterior lipiodol film revealing narrow termination of *cul-de-sac* due to anatomic variation. Opposite the lumbosacral interspace on the right side the lipiodol shadow is slightly indented by a protruded lumbosacral intervertebral disc.

Fig. 8. Anteroposterior lipiodol film revealing anatomic variation in the termination of the *cul-de-sac*. Usually the *cul-de-sac* terminates at about the level of the second sacral segment. In this case the termination is just caudad to the lumbosacral intervertebral space.

Two of our colleagues, Walsh and Love (9), have recently studied the meningeal response following the subarachnoid injection of lipiodol and they are quoted as follows:

TABLE III.—ACCURACY OF LIPIODOL EXAMINATION

Lipiodol Diagnosis	Patients Examined	No. Operations Performed	Errors of Interpretation	Errors of Omission or Commission	Total Errors
Protruded intervertebral disc	208	203	8 (3.9%)[1]	1 (0.5%)	9 (4.4%)
Tumors	45	43	4 (9.3%)	2 (4.7%)	6 (14.0%)
Hypertrophied ligamentum flavum	6	5	0	0	0
Miscellaneous: positive	32	19	5	0	5
Negative	126 (30.2%)	13	0	11[2] (8.7%)	11 (8.7%)
Total	417	283 (67.9%)	17 (6.0%)	14 (4.9%)	31 (11.0%)

[1] The percentages of error are calculated on the basis of "number operations performed" for the positive lipiodol diagnoses and for the total, but on the basis of "patients examined" for the negative diagnoses.

[2] Among these were five cases in which protruded intervertebral discs were found at operation but in which the *cul-de-sac* was short. As is explained in the text, it is doubtful whether these cases should be regarded as errors of omission. If these five cases are excluded, the percentage of error of omission or commission is reduced to 4.8 for negative lipiodol diagnoses and to 3.2 for total diagnoses, and the percentage of total error is reduced to 9.2 for total diagnoses.

"Our findings corroborate the findings of others that a transitory meningeal irritation occurs following the injection of iodized oil into the subarachnoid space. It is, however, of mild degree as evidenced by the changes in the spinal fluid. It is equalled as far as the acute phase goes, by the reaction to the intraspinal insufflation of air, in which Thurzo and Nagy reported an increase of from 400 to 3,000 cells in the spinal fluid of man with an accompanying increase of total protein and with concomitant signs of meningeal irritation. It is well known and has been demonstrated often that the subarachnoid injection of any foreign substance causes a meningeal reaction, the severity and duration of which depend on the irritating properties of the substance. When the reaction in the subarachnoid space to iodized oil is compared to the known reaction to numerous other agents, iodized oil may be classified as a substance provoking a mild and benign meningeal irritation.

"We have seen no clinical reaction to iodized oil that might not have been produced by a spinal or cisternal puncture with the withdrawal of spinal fluid alone and we agree in this respect with Globus. In the large number of laminectomies for removal of protruded intervertebral discs that have been performed at the Clinic at intervals varying from a few minutes to two years after the intraspinal injection of iodized oil, no visible evidence of irritation of the meninges or nerve roots attributable to the iodized oil alone has been noted at operation. It is probable, however, that the injection of iodized oil into the subarachnoid space in certain cases in which partial or complete obstruction of the circulation of the spinal fluid exists might accentuate the clinical symptoms. Since in these cases operation is indicated and should immediately follow the localization of the lesion, permanent damage is not done."

Frankly, we do not believe that either air or lipiodol is an ideal agent for intraspinal diagnosis, as each has certain limitations or disadvantages. A radiopaque solution, non-irritating to the meninges and capable of early elimination through the spinal fluid and blood, would be a great contribution to this whole problem and undoubtedly will come sooner or later. Until such a substance is developed, we believe that the wise and judicious use of lipiodol in properly selected cases is the most accurate means of visualizing lesions affecting the spinal cord and cauda equina.

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DISCUSSION

EDWARD L. JENKINSON, M.D. (Chicago): The essayists have left very little to say regarding the subject. They have certainly covered it thoroughly and I think I will have to resort to the time-honored plan of asking questions.

Regarding anomalies—or probably a better term is anatomic variations—in the spine, it has been our experience that most individuals who have these anatomic variations, such as spina bifida, incomplete union of the transverse processes, etc., seldom have symptoms unless they have had an injury and then, especially, if it becomes a medico-legal case. Of course then the anatomic variation becomes exceedingly important and it is the obligation of the radiologist to determine, or try to determine, whether the anatomic variation is due to the injury or to a simple anomaly. As you know, that is often difficult to prove to a jury or even to yourself.

I want to question Dr. Walsh regarding fluid protein. Most of the cases we have

done at our hospital have not shown an elevation of the fluid protein. I would also like to ask him what has been his experience as to the elevation of the fluid protein in the different parts of the spinal canal. Is the fluid protein higher adjacent to the lesion, either above or below, and normal some distance from the lesion?

Talking the other day with one of our colleagues at the hospital, he said he could see readily why there might be a definite elevation in fluid protein below the lesion, but he could not understand why it should be well above the lesion.

Talking to Dr. Camp a while ago, he told me there was a difference. I would like to hear what Dr. Walsh has to say about this subject.

One more thing about spina bifida. You undoubtedly have all read the recent articles and have probably seen a spina bifida involving the top of the sacrum, accompanied by multiple small ossicles. I wonder if anyone has been able to differentiate those or get any information using air or lipiodol in determining whether or not they are causing pressure on the cauda equina.

A variation in the caudal sac has been a perplexing subject as far as we are concerned. Dr. Camp displayed a couple of slides showing the variation in the caudal sac. In some of the patients we have examined, we have found this marked difference in the caudal sac. In some of them you will find the fluid will go well down into the sacral canal; in others, it will end abruptly. In the usual type, you have this conical shape of the end of the caudal canal. We have found a number of patients in whom the sac would end abruptly or be irregular, and it was impossible for us to say whether or not there was a complete block.

I would also like to ask if anyone knows the significance following a lipiodol injection in which you find the medium goes well down into the sacral canal and you find tremendously large nerve sheaths, often the size of your little finger. I am wondering whether or not they mean anything or whether anyone here has any information regarding their significance.

Dr. Chamberlain is to be congratulated on his work; he does unusually fine technical work. I can see how he shows a great many of these lesions that probably most of us cannot. That is our main reason for using lipiodol, namely, technical difficulties. Undoubtedly he is correct in saying that oxygen is probably the best medium to use.

I would like to ask Dr. Camp, in the operation for the removal of these discs, Do your neurosurgeons usually open the dura, and, if they do, do they attempt to remove or recover the lipiodol or do they usually use the transdural method, and is there more danger in using the transdural method or just going around the dura?

Another thing that we are perplexed about is the deformity that is occasionally found in the region of the conus. We had a rather unfavorable experience, in a man whom we thought was a malingerer. He had been working for an industry and was sent up for a lipiodol injection of the spinal canal. His case had been worked up very thoroughly by the neurologist, who decided a lipiodol examination was necessary.

Now we all know there is a hesitation in the passage of the oil in the region of the conus, but this man had a complete block. We were unable to get any of the lipiodol beyond the conus. It was a rather bizarre shadow, and did not look like a herniated disc. I thought the patient had a tumor. He was operated upon by a neurosurgeon and nothing was found to cause a complete obstruction, but the man incidentally improved and left the hospital. The diagnosis made by the neurosurgeon was an arachnoiditis. I would like to know what Dr. Camp has to say about some of these bizarre fillings.

L. Henry Garland, M.D. (San Francisco): Dr. Camp and Dr. Chamberlain have outlined in their usual masterly fashion the methods of diagnosis of spinal cord lesions using, respectively, lipiodol and air. Dr. Chamberlain dislikes lipiodol because he fears the results of meningeal irritation

produced by the oil. There is no doubt that immediately following the injection of a few cubic centimeters of lipiodol there are transitory meningeal reactions lasting from two to five days, and quite similar to those which follow the injection of air or any other foreign material into the spinal canal. Further, examination of the meninges some months or years following the injection of lipiodol reveals various degrees of meningeal thickening and fibrous tissue reaction. However, it is of interest to emphasize that no one has ever proven that clinical symptoms are associated with these late localized meningeal changes. For this reason, I personally regard lipiodol as superior to air for the diagnosis of certain spinal cord lesions.

In those patients in whom lipiodol is incompletely removed at operation (and it is always difficult to remove more than a little of it) and in patients who are not subjected to operation following injection of lipiodol, some of the oil remains in the lumbar section of the spinal canal and some scattered throughout the remainder of the cerebrospinal system. It is of interest to roentgenograph these patients' skulls at a later date and to find, in approximately one-half of the cases, globules of lipiodol scattered around the basal cisternæ and the third and fourth ventricles. Some of the lipiodol is fixed; a little of it is mobile. Stimulated by a case seen one year ago (kindly referred by Dr. Morrissey), I recently investigated a group of 35 patients who had had lipiodol injected into their spinal canals from one to twelve years previously. In approximately one-half of these cases, lipiodol residues were present in or about the base of the skull. Careful neurologic examination failed to reveal any findings that were not present prior to the injection of the lipiodol (the neurologic examinations being conducted by Dr. Fender). This material will shortly be published and will, I believe, confirm the observations of many other writers that small amounts of lipiodol are clinically harmless when injected into the subarachnoid system of a suitably selected patient.

JOSEPH C. BELL, M.D. (Louisville, Ky.): It is a pleasure and privilege to discuss this particular problem, especially the question raised by Dr. Camp concerning the amount of lipiodol used in these examinations. I have worked with three neurosurgeons on this problem during the past three years. Our experience has been limited to approximately eighty cases which have been operated upon and in which organic lesions encroaching upon the neural canal have been demonstrated. The majority of these patients have suffered from low back pain and most of the lesions have been in the lumbosacral area. A high percentage of the obstructing lesions removed have proven to be herniated nuclei.

We feel very definitely that 2 c.c. of lipiodol is adequate for this examination, at least in the lumbar and lumbosacral areas where most of the lesions under discussion occur. We have found that the behavior of the lipiodol column in the dorsal area may be unusual at times and it is possible that an examination with 5 c.c. may prove more satisfactory in this region than one with 2 c.c., but our experience with both amounts makes this seem unlikely. Just what has been responsible for the bizarre appearance of the column in the dorsal area at times I do not know with certainty, but believe that intervertebral discs may normally protrude into the canal in this area at times.

I have been very much interested in Dr. Chamberlain's work with air and have discussed the use of this medium with Dr. R. Glen Spurling, of Louisville, Ky. We have agreed to give the method a thorough trial. Our conclusions were that the air study should be done first. If evidence of a lesion within the canal is found, no further investigation should be done, but if the examination with air or oxygen is negative and the patient has definite evidence of an organic lesion from the neurologic standpoint, then an examination with lipiodol should be made.

MAURICE N. WALSH, M.D. (*closing*): In regard to Dr. Jenkinson's question about

the region in which spinal puncture is to be performed, we do feel that spinal puncture below the site of the lesion could be expected and we feel that it usually does produce a fluid which has a high concentration of total protein. However, spinal puncture above the site of the lesion will often, for some reason which we do not understand, produce a fluid which also contains an increased amount of total protein.

Recently, Eaton and Woltman, of the Mayo Clinic, have been trying the experiment of taking the spinal fluid in two fractions and determining the concentration of total protein in each. It has been found that, in the first fraction, the concentration of total protein is often higher than it is in the second, and I feel that this may be of some help in increasing the percentage of cases in which an increased concentration of total protein is found in the spinal fluid.

I was much interested in Dr. Chamberlain's excellent demonstration of the effect of posture on the protrusion. We have noted this in a cadaver, in which we were dissecting the lumbosacral nerve roots. We found that hyperextension of the back would cause a definite protrusion of the fourth lumbar disc which was already protruded, whereas hyperflexion or flexion would cause the protruded disc to be drawn back into the body of the vertebra.

JOHN D. CAMP, M.D. (*closing*): In answer to Dr. Jenkinson's question about the removal of lipiodol and opening of the dura, I would say that this depends a great deal on what is found at the time of laminectomy. As a general rule, the neurosurgeon prefers to remove the disc extra-durally, but this cannot always be done without troublesome bleeding from some of the veins which are usually congested. The transdural approach is frequently easier to accomplish and is associated with less bleeding.

In the great majority of cases, when an extra-dural removal is done, the dura is nicked and the lipiodol is washed out by means of a catheter and saline. In the cases in which radiographs were made after the laminectomy, it was quite evident that the great majority of the lipiodol had been removed.

In regard to the bizarre findings in some cases that Dr. Jenkinson has mentioned, I can say that we have had a few similar experiences which I am unable to explain. These cases, fortunately, are very few. When the lipiodol defect is not characteristic of a particular type of lesion, we usually report our findings as a lesion or an atypical lesion or an atypical deformity. It is interesting that the great majority of patients in which a lesion cannot be demonstrated surgically seem to be relieved of their symptoms following the laminectomy and, after all, that is the primary object of our treatment.

In all fairness to the work which Dr. Chamberlain has done, I would like to say that I personally believe that air myelography is going to be used more than it has been in the past. We certainly are going to use it more than we have. However, from our experience so far I question its accuracy as compared to that of lipiodol. We can use air first, if we wish, and supplement it in doubtful cases with lipiodol, if the symptoms indicate. Certainly many lumbar lesions show beautifully with air. Air is a little more troublesome to use and the findings are not always as easy to interpret as those observed with lipiodol, but I do think we should try it more than we do.

EVALUATION OF VARIOUS DIAGNOSTIC PROCEDURES USED IN THE STUDY OF THE BREAST, WITH PARTICULAR REFERENCE TO ROENTGENOGRAPHIC EXAMINATION[1]

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THE radiologist is intimately concerned about the accuracy of diagnosis in tumors of the breast. This interest is forced upon him by his responsibilities as a therapist in the pre-operative irradiation of cancer of the breast and in the irradiation and clinical care of inoperable cancers. The administration of thorough, effective irradiation to the cancerous breast is a major procedure which necessarily inflicts considerable inconvenience, discomfort and, at times, pain on the patient. In our opinion, heavy pre-operative irradiation is not justified unless the diagnosis of cancer is reasonably certain. An indurated chronic cystic mastitis can give the clinical picture of scirrhous carcinoma. Cases labeled inoperable carcinoma should be proven before being given a final diagnosis. Fat necrosis with fixation of the skin, associated with marked peritruncal pulmonary fibrosis or defects in the skull, can simulate cancer of the breast with metastasis. An adequate biopsy is necessary for the establishment of the diagnosis and the avoidance of error in such cases.

The radiologist is also interested in the diagnosis of breast lesions from the viewpoint of the diagnostic roentgenologist. It is our belief that in selected cases roentgenographic examination of the breast contributes information not provided by other methods. In the majority of cases it adds but little of practical value to what can be learned from careful inspection and palpation of the breasts. Roentgenography occupies a position between transillumination and biopsy in the diagnosis of breast lesions.

The anatomy, physiology, and pathology of the breast will be briefly reviewed in order to facilitate our discussion of problems in differential diagnosis.

Anatomy and Physiology.—The adult female breast is composed of from 12 to 20 lactiferous glands, each of which constitutes a lobe of the breast. The ducts converge at the nipple. Peripherally, the ducts branch into ductules with terminal secreting acini. The glands are supported in position by suspensory ligaments attached to the skin; and by means of intralobular and interlobular connective tissue. The breast tissues are enveloped in fat situated between the lobules, between the breast and the skin and between the breast and the chest wall. Plain roentgenography of the breast is made possible by the contrast in density which exists between the radiolucent fat and denser glandular and connective tissue structures.

The development, structure, and function of the breast is controlled directly by the ovary and indirectly by the pituitary according to Behan (3). The rudimentary ducts of the child elongate, branch, and develop rudimentary acini at puberty due to stimulation by estrin from the maturing follicles and progestin from the corpora lutea ushered in at that time. Pregnancy greatly increases the output of both estrin and progestin. This leads to increased enlargement and lateral branching of ducts and to maturation of the secretory acini. The lumen of each duct widens into an ampulla before reaching the nipple. Parturition is associated with increased proiactin from the pituitary. This engorges the breasts and stimulates the secretion of milk. The non-lactating multiparous breast shows regression of acini but some enlargement of ducts persists. At the climacteric, the glandular tissue in

[1] Presented before the Twenty-fourth Annual Meeting of the Radiological Society of North America, at Pittsburgh, Nov. 28–Dec. 2, 1938.

the breast atrophies while connective tissue and fat increase. The fat is frequently separated into lobules by intervening connective tissue septa.

The menstrual cycle has a marked effect on the morphology of the breast. A physiologic hyperplasia of the epithelium of the lactiferous ducts and acini as well as of the periductal and periacinous connective tissue precedes each menstruation. This cyclical hyperplasia and involution of the breast depends on the variable level of estrin and progestin produced by maturation of the graafian follicles and by development and regression of the corpora lutea. This physiologic cyclic hyperplasia of the breast is called *mazoplasia* (breast-growth) by Cheatle and Cutler (4). The process is reversible. Deviations from normal hyperplasia or involution lead to various pathologic states of the breast such as chronic cystic mastitis, and probably to intraductal papilloma and fibro-adenoma.

Pathology.—Excessive hyperplasia of the glandular epithelium or periductal connective tissues may occur. In case the intraductal epithelial hyperplasia becomes pathologically extensive and persistent, the ducts become enlarged, with formation of cysts and distention by desquamation of cells into the lumina.

This condition is commonly known as *chronic cystic mastitis:* the more descriptive term applied by Cheatle (4) is *cystiphorous desquamative epithelial hyperplasia.* The occurrence of multiple small cysts with extensive epithelial hyperplasia is known as *Schimmelbusch's disease.* The coalescence of multiple cysts leads to larger cysts, descriptively called *blue-domed cysts* by Bloodgood. These conditions are all manifestations of cystiphorous desquamative epithelial hyperplasia.

Localized overgrowth of the periductal or periacinous connective tissue, with inclusion of a few glandular elements, forms a fibro-adenoma. This encapsulated tumor appears to result from some incompletely understood disturbance of endocrine balance. Intraductal papilloma represents a localized overgrowth of the epithelium, usually occurring in the ampullary region. Papillomas are usually multiple and are frequently bilateral. Cysts may result from cystiphorous disease, retention of secretion or degeneration of a solid tumor. In general, cysts are adherent to surrounding structures. A galactocele is a cyst formed by local retention of milk in a lactating gland. Fibro-adenomas or carcinomas may undergo cystic changes. Carcinoma may develop in the wall of cysts, particularly in the smaller cysts, although cystic disease does not appear to be associated with any predisposition to the development of carcinoma, according to Bloodgood. A cyst containing clear fluid is usually benign, whereas a cyst containing blood is usually associated with a malignant neoplasm. Lipomas represent about 1 per cent of all tumors of the breast and may occur at any age, according to Menville (20).

Carcinoma of the breast can arise at the nipple, in the larger ducts, in the smaller ducts, or in the acini. The grade of malignancy increases roughly according to the site of origin in the order named, according to Cutler (5). Proliferation of the cells into the ducts produces an intraductal carcinoma. Paget's disease is a form of carcinoma of the areola usually associated with intraductal carcinoma within the breast. Low grade, fairly well differentiated adenocarcinomas develop in the large ducts and grow to large size before metastasizing. Mucoid degeneration or production of mucin in an adenocarcinoma gives rise to the so-called *colloid type* of carcinoma. The poorly differentiated carcinoma may grow as a compact mass of cells, which is called *medullary* or *encephaloid* in type. The patient may develop a connective tissue barrier along the tumor as Nature's effort to restrain growth, called a *scirrhous type* of carcinoma. The borders of the scirrhous tumor are grossly irregular and the breast is deformed by the connective tissue proliferation and by invasion of the suspen-

sory ligaments. Early obstruction of lymphatics by a very highly malignant carcinoma produces an edema of the breast simulating a diffuse inflammation. Lesions of this type are often called *inflammatory carcinomas*. Sarcomas represent only about 2 per cent of malignant tumors of the breast, and usually represent low grade malignant changes in fibro-adenomas.

Non-specific inflammatory disease of the breast may take the form of infection in cysts, an abscess localized to one lobule, or —rarely—a diffuse mastitis. Tuberculosis of the breast produces a chronic granuloma which may simulate carcinoma. Fat necrosis appears to result from local impairment of blood supply, being commonly associated with a history of trauma or with pendulous breasts (20). The broken-down fat sets up a localized low grade chronic inflammatory reaction. Hemorrhage into the breast may result from rupture of a vessel by trauma, infarction, or hemorrhagic tendency.

Case History.—The history is of value in revealing the constitutional background of the patient, the progress and duration of the lesion, and symptoms referable to metastases. A family history of cancer of the breast should make the physician doubly critical in considering cancer and as to advising the patient to report for periodic examination of the breasts. Cancer of the breast is to a certain definite extent a familial disease, as is well known to clinicians and as has been proven by Slye (31) and other investigators. It is not necessarily associated with any increased frequency of cancer in other organs.

The recognition by the patient of a lump in the breast or axilla which has shown progressive growth and deformity of the breast or nipple is very suggestive of cancer and must be so considered until proven otherwise.

The most frequent cause of nodularity or lumps in the breast varies somewhat with the age of the patient. Mazoplasia and fibro-adenomas are most common from puberty to 35 years and carcinoma beyond 45 years. On the other hand, any of these lesions, and particularly carcinoma, can occur at any age.

The examiner must learn the status of his patient in relation to her menstrual cycle, pregnancy, lactation, and the menopause. Pain in the breast may be due to cancer or to a benign lesion. Cyclic premenstrual recurrences of pain are usually associated with physiologic disturbances, or a benign lesion such as mazoplasia or cystiphorous desquamative epithelial hyperplasia (chronic cystic mastitis). A history of injury is important in evaluating the possibility of fat necrosis, or hematoma. Bleeding from the nipple usually results from carcinoma or papilloma. Discharge from the nipple may result from carcinoma, papilloma, cystic disease, or pregnancy. The possibility of distortion of the breast by previous abscess, infection, operation, or congenital malformations should be ascertained.

Symptoms of metastasis are referable to involvement of the skeleton, peripheral nerve roots, central nervous system, respiratory tract, and gastro-intestinal tract. The patient must be questioned in regard to backache, girdle pains, pains in arms or legs, paresis, headache, visual disturbances, cough, dyspnea, dysphagia, and anorexia. Occasionally, asymptomatic metastasis may be demonstrated by appropriate roentgenograms.

Inspection.—Asymmetry in the size, shape, or position of the breast should be noted, with the patient in a sitting position. A scirrhous carcinoma of the breast or old inflammatory process shrinks the breast, retracts its contour, and elevates its position. Enlargement of the breast results from a bulky tumor or edema secondary to lymphatic obstruction, by neoplasm, or by inflammation. Plasma-cell mastitis, described by Adair (1), differs from carcinoma in giving a definite history of antecedent infection and very rapid recession after from 100 to 300 roentgen units. Pitting of the skin may result from retraction of suspensory ligaments in scirrhous carcinoma or, rarely, from inflammation. Edema from any

cause produces the so-called "orange peel" appearance, from dimpling by the deeply fixed sebaceous glands and suspensory ligaments. These changes are best shown by tangential light. Retraction of the nipple may be congenital in rare cases or it may result from shortening of ducts on one side by previous inflammation or neoplastic infiltration. An eczematoid erosion of the nipple and areola usually distinguishes Paget's carcinoma, even though no mass is palpable in the breast. A subcutaneous tumor is often suggested by a bulge in the contour of the breast.

Discharge from a nipple may show only as a stain on the clothing or a crust on the nipple; in other cases, discharge may be expressed by massage of a duct. Areas of hemorrhage show an ecchymotic discoloration through the skin. Involvement of the skin may be suggested by a raised plaque, a fixed puckering, or an ulceration. Elevation of the arms above the head aids in demonstration of some masses. Fixation to the pectoral muscle is indicated by an increased upward and outward movement of the mass on raising the arms. Fullness of the supraclavicular region or axilla suggests metastasis to regional nodes, as does also edema of the arm.

Palpation.—Palpation reveals presence of masses in the breasts, fixation of these masses, texture of the skin, enlargement of lymph nodes, and local tenderness. Masses should be examined with reference to their size, number, consistency, contour, delimitation, distribution, tenderness, and mobility. The normal breast is examined first. The hand is placed flatly over the breast and rotary compression applied through the breast against the chest wall, with the patient recumbent. Abnormal masses are felt to roll beneath the fingers. A careful bimanual examination of the tumor mass is best done with the patient in a sitting position. A finely nodular induration, vaguely palpable to the flat palm, often multiple and bilateral, but occasionally confined to one lobe, suggests chronic cystic mastitis. Single or multiple, sharply circumscribed, freely movable masses, with no axillary nodes, suggest fibro-adenomas. A single hard mass suggests carcinoma, especially if associated with indefinite outline, fixation to surrounding tissues, or firm, non-tender enlargement of axillary nodes. Dimpling of the skin by fixation can often be brought into evidence, with elevation of the breast, by compression of it between the hands. A leathery thickening of the skin suggests edema from inflammation of neoplastic obstruction. Congenital retraction of the nipple can often be reduced by manipulation. Movement of a mass by traction on the nipple shows that the mass is connected to the ducts. Massage along the ducts and pressure on the nipple may express blood, purulent discharge, serous fluid, or milky secretion. Blood suggests intraductal papilloma or carcinoma. Viscid, greenish discharges suggest cystic degeneration and the possibility of infection. Serous fluid signifies simple cysts communicating with the ducts. A milky secretion usually signifies recent pregnancy.

Examination for evidence of regional adenopathy must consider the subpectoral, subscapular, axillary, subclavicular, supraclavicular, and cervical nodes. The subpectoral nodes are examined by inserting one hand, palm upward, beneath the pectoral muscles and the pectoral fold. Enlarged or indurated lymph nodes are felt to roll between the hands during a compressory-rotary motion. Proper examination of the axilla is an important and too often abbreviated procedure. The patient's arm is abducted and the examiner's hand is placed high in the axilla. The arm is then lowered to the side and the tips of the fingers are thrust into the apex of the axilla, keeping close to the lateral or humeral wall. A compressory–rotary type of motion permits detection of the enlarged nodes as they are rolled over the ribs. The pectoral fold can now be grasped between the thumb and fingers. Grossly enlarged, agglomerated, or ulcerated nodes class the case as probably incurable by radical surgery. Enlargement of supraclavicular nodes is nearly always asso-

ciated with other involvement of the high axillary nodes and renders the lesion inoperable. The skull, spine, ribs, and pelvis should be examined for local tenderness. The abdomen should be palpated for enlargement of the liver, masses, and fluid.

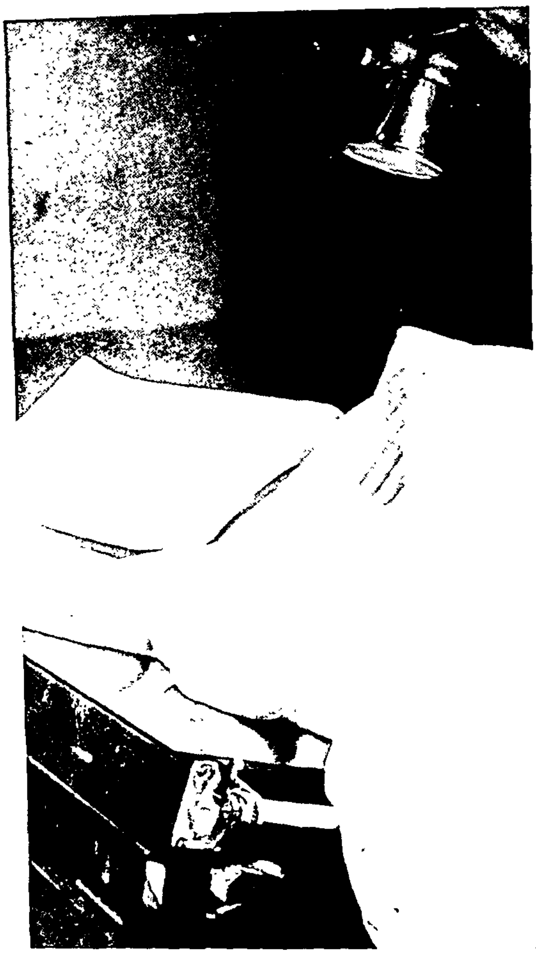

Fig. 1. Placement of patient for roentgenographic study of the breast using the Potter-Bucky grid.

Transillumination.—The penetration of light through tissues decreases progressively in the following general order: air, clear fluid, fat, cloudy fluid, cellular and fibrous tissue, and blood. The periphery of the normal breast, being composed of fat, is quite translucent. The parenchymatous glandular portion of the breast is more opaque and casts an indefinite shadow which varies in density with the physiologic state of the breast. The blood vessels stand out in bold relief, as dark lines which can be erased by local pressure. Transillumination was developed by Cutler (5).

Transillumination is primarily of value in the recognition of serous cysts and in revealing intraductal hemorrhage associated with papilloma. A clear, thin-walled serous cyst transilluminates with the same clarity as a hydrocele. Varying degrees of opacity may occur in a cyst due to a dense wall, turbidity due to desquamated material, or dense opacity due to blood. Papillomas cast no shadow and are not directly discernible, but they can often be apprehended and located by the associated hemorrhage and retention of blood in the ducts. A dark, dense, persistent localized shadow is then present. In the absence of retained blood, transillumination gives no evidence of papilloma. An extraductal hematoma, due to trauma or apoplexy, shows a darker central portion and a fluffy irregular border due to extravasation. A lipoma is less translucent than a clear cyst but much less opaque than a cloudy cyst. Fibro-adenoma casts a fairly distinct, well-outlined shadow. An infiltrating scirrhous carcinoma, two or three centimeters in size, shows a poorly delimited dense shadow merging with the matrix of the breast. The matrix of the tumor bed moves with the tumor. Small carcinomas present no changes. Compact malignant tumors cannot be differentiated from benign tumors.

Plain Roentgenography.—Visualization of the mammary tissues by x-ray was first attempted, in 1913, by Solomon (32), who examined excised specimens. Goynes, Gentil, and Guedes (9), in 1929, and particularly Warren (34), in 1930, announced the value of roentgenography in the differentiation of breast tumors. In 1929, Ries (25) reported visualization of lactiferous tubules by injected lipiodol but only to condemn the procedure in view of a resulting abscess. Further contributions to the subject have been made by Paschetta (22), Seabold (29), Lockwood (16), Romagnoli (27), Vogel (33),

Fray and Warren (6), Ritvo, Butler, and O'Neil (26), Gershon-Cohen (7), Ledoux-Lebard (14), and others. Transillumination and roentgenography are both shadowgraphic methods. The penetration of light depends on the translucency or clarity of structures, whereas the record given by x-ray examination depends entirely on differences in density or specific gravity of the adjacent structures. Each method contributes information not provided by the other. Roentgenography is most helpful in the examination of bulky obese breasts in which palpation and transillumination are unsatisfactory. Furthermore, it provides a stereoscopic permanent record which can be used for reference, study, or demonstration to the patient. The gross internal structure of a lump or nodularity can at times be portrayed and the delimitation of the mass can be estimated. Non-palpable enlarged axillary lymph nodes can be demonstrated in a few cases.

Various technics of roentgenography have been described. We have found the following procedure simple and satisfactory. The patient is placed in the oblique dorsal recumbent position as shown in Figure 1, with the breast being examined supported by a 23° angle board. The arm is abducted, elbow flexed, and hand placed on the head. The opposite shoulder is elevated by sandbags, pillows, or another angle board. The x-ray beam is projected tangentially along the chest wall through the base of the breast, including the axilla on the film. The opposite breast is drawn laterally out of the field by the patient's hand. Movement of the left chest wall due to cardiac pulsation is troublesome but can be minimized by firm support, arrest of breathing, and rapid exposure. Use of a portable Potter-Bucky grid improves contrast and definition in the thick bulky breast but adds little clarity to the detail in a thin pendulous breast. Detail screens are desirable. Cardboard film holders give a maximum of soft-tissue detail in the very thin breast but are unsatisfactory in the bulky breast, due to obscuration produced by a multitude of overlapping anatomic structures and a lack of contrast. The technical factors employed will vary with the problem and the equipment at hand: from 30 to 50 kv., 75 cm. distance, and from 50 to 150 ma.-sec. with cardboard holders, from 25 to 100 ma.-sec. with grid and screens, or from 10 to 50 ma.-sec. with screens alone. Stereoscopic studies allow more accurate differentiation and orientation. The opposite side is examined for comparison in the case of borderline lesions.

The breast is well adapted for portrayal by roentgenography due to the natural contrast existing between the radiolucent supporting fatty tissues and the more radiopaque glandular tissues. Lockwood (18) has pointed out that four zones of the breast are discernible in plain roentgenograms: (1) cutaneous zone, (2) the radiolucent pre-mammary fatty layer crossed by suspensory ligaments, (3) denser glandular zone with confluence of structures toward the nipple, and (4) the relatively radiolucent retromammary zone between the base of the breast and pectoral muscles. Mazoplasia is evidenced by a hazy frond-like accentuation of the glandular and ductal pattern throughout the breasts, according to Lockwood (17). Cyclic development and regression are seen in serial studies, being maximal from about seven to ten days before the onset of menstruation, according to Reimann and Seabold (23).

Cystiphorous desquamative epithelial hyperplasia or chronic cystic mastitis begins as a mazoplasia which fails to regress. A diffuse or localized thickening or poorly defined nodularity of ductal shadows results. Warren (34), Fray (6), and Ritvo (26) state that cysts containing fluid are relatively radiopaque, whereas Seabold (29), Lockwood (16), and Ledoux-Lebard (14) state that cysts are radiolucent centrally. Both groups of observers may be correct. However, radiolucence of a cyst can result only in the event that the specific gravity or density of its content is relatively lower than that of surrounding tissues. On this basis, small cysts might

be radiolucent if filled with desquamated cellular detritus with a high content of fat or lipoids, as described by Lepper and Weaver (15). Large cysts, in our experience, are relatively radiopaque. The mucinous fluid from a radiopaque degenerating cystic fibro-adenoma had a specific gravity of 1.022. Multiple radiolucent areas in the nodular involuting breast frequently represent lobules of fat enmeshed in connective tissue. A radiolucent area within a wall is at times falsely suggested by vascular shadows arching through perimammary fat.

A lipoma in any region of the body presents a diagnostic appearance in the roentgenogram. Fat has the lowest density of any soft tissue, and the lipoma is, therefore, the most radiolucent tumor of soft tissues. The shadow of the tumor is not particularly evident, having the same general density as the pre-mammary fat. A variable fibrous network is often evident within a lipoma on stereoscopic examination. Lipoma of the breast is shown in Figures 2-*A* and 2-*B*.

A fibro-adenoma in contrast to the lipoma casts a dense, rather sharply demarcated, shadow. In the plain film, fibro-adenoma cannot be differentiated from a cyst or a compact carcinoma. It can be differentiated by carbon dioxide injection.

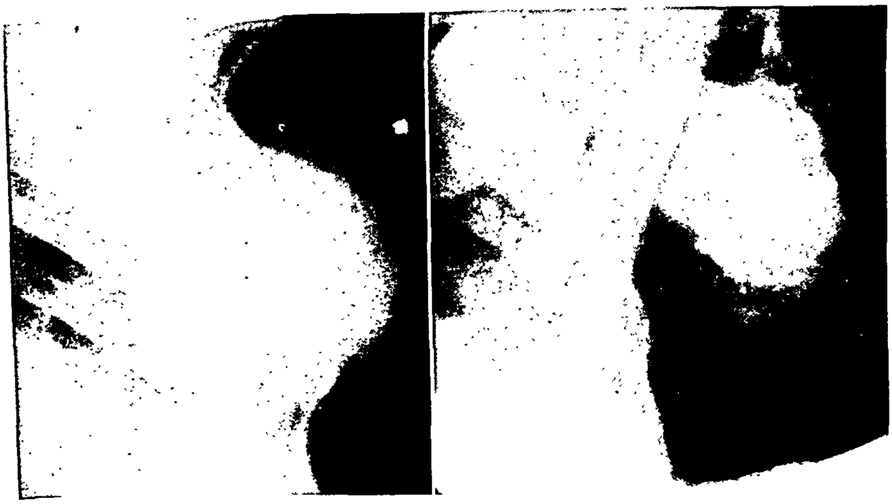

Fig. 2-*A*. Fig. 2-*B*.

Fig. 2-*A*. Lipoma of the breast diagnosed in plain film by radiolucency of the tumor mass.
Fig. 2-*B*. Carbon dioxide insufflation shows encapsulation of tumor, but outline is hazy in comparison with fibro-adenoma in Figure 4.

Carcinoma of the breast can be apprehended about as accurately by inspection and palpation as by roentgenography. Roentgenography assists in the diagnosis by the recognition of certain benign lesions which might otherwise be considered cancer. The small early carcinoma can be diagnosed only by biopsy. The *medullary type* of growth simulates cysts and fibro-adenomas which can often be differentiated by aspiration and by æromammograms. The *scirrhous type* of carcinoma shows a dense irregular infiltrating shadow. The tumor grows centrifugally, invades surrounding tissue, and grows along the ducts, the lymphatics, and the suspensory ligaments. Retraction of the nipple, distortion of surface contour, and infiltration of perimammary fat result. Invasion of the retromammary fat space can sometimes be shown in cases in which physical signs of fixation are in doubt. Edema or congestion of the breast

due to lymphatic obstruction, inflammation, or post-radiation erythema show only a generalized increase in density and lack of anatomic detail.

Aeromammography.—Additional roentgenographic contrast and demonstration of cleavage planes were provided with injection of air into the perimammary tissues by Baraldi (2), in 1935. We have previously (10, 11, 12, 13) pointed out the superiority of carbon dioxide due to rapid absorption and lessening of the possibility of a gas embolus. The procedure is simple and causes only slight distress to the patient. It is not advocated in cases of evident carcinoma due to the theoretical possibility of opening pathways which might facilitate dissemination.

The technic of injecting carbon dioxide is conducted under usual aseptic precautions. The equipment now in use consists of an inexpensive football bladder distended with carbon dioxide connected with a two-inch 22-gauge infiltration needle through rubber tubing and a propelling mechanism as shown in Figure 3. A preliminary wheal of 1 per cent solution of novocaine can be injected intradermally but is not necessary. The carbon dioxide is injected beneath the breast into the retromammary space, and then into the premammary and peri-areolar regions. The gas is forced through the tissues by gentle pressure over the site of injection. Notation must be made of regions not injected, as in Figure 5, to aid in interpretation.

The encapsulation of fibro-adenomas is very convincingly demonstrated by æromammograms shown in Figure 4. No other tumor of the breast shows this clear-cut encapsulation. Lipomas show less contrast and a fuzzy encapsulation; cysts merge with surrounding breast tissue and lack clear-cut encapsulation; carcinoma shows a frayed, poorly delimited border. Fixation of a tumor mass to the skin or chest wall is well demonstrated in Figure 5. Fixation usually results from carcinoma, but may follow inflammation or scar tissue. Infiltration of retromammary tissues can be demonstrated by this method in instances in which it cannot be established by physical examination.

Aspiration of possibly cystic tumors

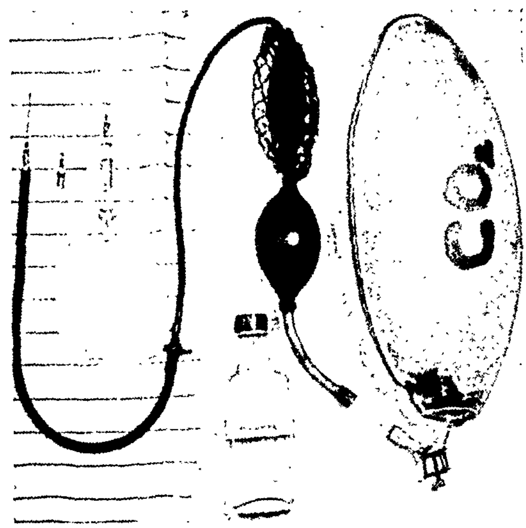

Fig. 3. Apparatus for insufflation of the breast by carbon dioxide. The reservoir consists of a rubber bladder from which gas is pumped into the breast.

frequently yields helpful information from a study of the fluid, as discussed by Mathews (19). Clear serous fluid indicates a benign cyst; bloody fluid is associated with carcinoma in the majority of cases and calls for surgical removal. The inner contour of the cystic cavity and papillomatous ingrowths can be visualized with stereoscopic films following replacement of the fluid by air. Absence of fluid indicates a solid tumor.

Intraductal Contrast Mammography.—Intraductal injection of radiopaque material was reported as a practical procedure by Hicken (10) in 1937, and later described by Oselladore (21). Intraductal mammography is to be considered only in the case of a patient with a discharge from the nipple. It is contra-indicated in case of acute infection, obvious carcinoma, occlusion or deformity of duct at the nipple by any cause, and by technical difficulty in entering the duct. Entry is very difficult in the virginal and obese breast. This is not a complicated procedure but requires much skill and care in execution.

It carries some risk of extravasation, stasis, and infection.

The technic of intraductal injection must be conducted under strict aseptic precautions. The breast is cleansed and hot moist compresses applied for five or ten minutes. The moisture softens any plugs of inspissated material which may be in the ducts and the heat relaxes their sphincters. A gentle stripping massage of the nipple will express a tiny droplet of secretion or blood at the orifice of the involved ducts. The end of a blunt No. 27 hypodermic needle or breast cannula is suspended vertically above the orifice. It should drop into the duct under the weight of the syringe and will slide back and forth in the duct for the distance of about one centimeter. No attempt should be made to force a cannula into a duct which is not definitely patent. About 0.5 to 2.0 c.c. of contrast medium is injected. The patient experiences a mild discomfort which radiates from the nipple to the periphery of the injected lobule. A sharp, severe pain calls for immediate cessation of injection and suggests extravasation. Stereoroentgenographic studies are then made.

Fig. 4. Fig. 5.

Fig. 4. Fibro-adenoma diagnosed after carbon dioxide insufflation by distinct encapsulation of the tumor, in comparison with lipoma shown in Figure 2-*B*.

Fig. 5. Fixation of carcinoma of the breast to skin and chest wall, shown by carbon dioxide insufflation: superior pole of breast had not been injected.

Contrast media for intraductal mammography should combine dense radiopacity to show fine detail, low viscosity to permit injection, retention during an interval sufficient to allow roentgenography, lack of serious irritation, and satisfactory elimination from the ducts. Thorotrast has been discontinued due to inflammation

resulting from extravasation, prolonged retention in the ducts, and radio-activity. Injurious effects have also been reported by lumen. The appearance is rather characteristic. Papillomas are commonly multiple and may be bilateral.

Fig. 6. Fig. 7.

Fig. 6. Intraductal papilloma demonstrated as a filling-defect in the ampulla of the lactiferous duct. Radiopaque medium had been injected aseptically into the discharging duct. (Roentgenogram contributed by T. T. Harris, M.D.)

Fig. 7. Dilatation of lactiferous duct with large deeply situated communicating cyst demonstrated by intraductal injection of opaque medium.

others (24, 28). Skiodan viscous (Winthrop), consisting of 40 per cent skiodan in 20 per cent of acacia, is the most satisfactory medium known to us at the present time. The skiodan is absorbed within about fifteen minutes but the acacia probably remains in the duct for some time. Oselladore (21) has successfully employed Uroselectan B. Diodrast can be used but, in general, it is absorbed too rapidly to permit satisfactory roentgenography. Iodized oil is too viscid for injection into the lactiferous ducts.

Papilloma usually shows as a filling defect within the dilated ampullary portion of a duct (Fig. 6). It may show as an area of compression or deviation of the ductal

Cysts communicating with the breast show as saccular pockets along the ductal tree (Fig. 7). They usually represent cystic changes produced in advanced chronic cystic mastitis. A cyst containing much desquamated cellular débris reveals a granular, flocculent shadow.

The phantom tumor of the breast, which comes and goes, is usually a cyst which communicates with a duct when collapsed. It can be demonstrated by injection of the discharging duct. Cysts which do not communicate with the duct can be diagnosed by direct aspiration and demonstrated roentgenographically after injection of air.

Visualization of the lymphatics of the

breast by the injection of radiopaque materials is, in our opinion, of no practical value at this time. We have observed visualization of lymphatics and pectoral nodes in one case following intraductal injection of a lipoiodine (Ciba) derivative. Gilbride (8) has observed prolonged visualization of lymphatics following injection of "Lympholan" (0.25 c.c.) in vicinity of the tumor. We believe that these are as yet fortuitous observations and have no practical application. Enlarged nodes are often demonstrated in plain roentgenograms but neoplastic and inflammatory nodes cannot be differentiated.

Metastases.—The roentgenographic demonstration of distant metastases in chest or skeleton may aid in the differential diagnosis of a mammary lesion. In case the signs of metastasis are questionable, we do not believe that mastectomy should be withheld. Inadequate treatment to the patient without real metastases may cost the patient's life. Post-radiation fibrosis and residual inflammatory changes from pulmonary infections can simulate metastases in the lungs. Inflammatory disease, old traumatic changes, and developmental variations can simulate metastases in the skull, spine, and pelvis.

Limitations of Roentgenography.—Roentgenography of the breast is only another method of gross examination. There is a wide gap between gross findings and the revelations of the microscope through which details are magnified from 50 to 800 diameters. Microscopic areas of cancer cannot be diagnosed by the x-ray. Early carcinoma associated with chronic cystic mastitis and malignant change occurring in a benign tumor of the breast cannot be recognized in the roentgenogram. Even the microscopists may be in a quandry and differ in their opinions regarding some of these borderline lesions. The irregular infiltration, distortion, and fixation of a scirrhous carcinoma can be simulated roentgenographically by various benign lesions such as fat necrosis and inflammatory scar tissue. Roentgenographic study is primarily of value in the borderline case in which accumulated evidence points toward a benign lesion and yet doctor or patient desires further reassurrance. Lockwood (17) states, "The roentgen examination of the breast is not offered as a substitute for other methods but as a valuable and accurate addition to the present methods for the recognition of cancer as well as other diseases of the breast."

Biopsy.—Biopsy is indicated in those cases in which there is any persisting uncertainty regarding the benignity of a lesion in the breast or axilla. A biopsy is also indicated in those cases of carcinoma of the breast which are to be treated by irradiation alone, as emphasized in the opening paragraph. Biopsy provides a permanent record of the exact histopathology. The treatment of a benign lesion under the mistaken diagnosis of cancer can thereby be prevented. The diagnosis, which is necessary for scientific evaluation of final results and for making an intelligent prognosis, is definitely established by biopsy.

A proper bioscopic examination requires co-operation between surgeon and pathologist. The surgeon must select a representative area, remove adequate tissue, and deliver it to the pathologist in good condition. The pathologist must properly mount, section, stain, and interpret the tissue. Inadequacies may occur at any point.

Aspiration biopsy, as developed by Stewart (30) and practised at the Memorial Hospital, is ideal for biopsy prior to irradiation, due to the minimum amount of trauma. A positive biopsy is very helpful but a negative aspiration biopsy is not significant. Small tumors can be missed and aspiration can fail to dislodge cells from fibrous tumors or scirrhous carcinomas. The aspirated material is examined as a smear. The efficacy of the procedure will vary widely with the experience of the surgeon and pathologist. *Punch biopsy* provides a larger piece of tissue, thereby permitting section. It does, however, have the same general limitations shown by aspiration biopsy.

Incisional biopsy is more reliable and informative but it also consumes more time and provokes more local reaction in irradiated skin. In case the lesion is small and of doubtful nature, it is best that the entire tumor mass and some adjacent normal tissue be removed at the biopsy. Such biopsies should be done under circumstances which permit a radical mastectomy immediately, if it be indicated. The periphery of a large tumor is more representative than its center since the center is often seminecrotic. The high frequency endothermic loop gives a relatively bloodless, well cauterized tumor surface in case only a small fragment is removed. A skin incision made by a scalpel heals more rapidly and tolerates radiation somewhat better than an endothermic incision. It is more satisfactory to remove an enlarged regional node than to attempt biopsy of an engorged breast in which the primary lesion is obscured by generalized edema. Preoperative biopsy of questionable supraclavicular nodes may detect the fruitlessness of proposed radical mastectomy. In certain instances of extensive diffuse cystiphorous disease of the breast, examination of the whole breast may be necessary for diagnosis or exclusion of carcinoma. Capable pathologists will still differ somewhat as to the point at which they draw the line between benign intraductal hyperplasia and carcinoma.

SUMMARY

1. The fundamental importance of a pertinent history and thorough physical examination in the diagnosis of mammary lesions is emphasized. Roentgenographic evidence must be correlated with clinical findings for full evaluation.
2. Roentgenographic examination of the breast offers diagnostic evidence in certain borderline lesions; being most helpful in recognition of lipomas, fibroadenomas, intraductal papillomas, and communicating cysts.
3. Plain films of the breast differentiate lipomas from other tumors by the high radiolucence of fat. Examination of the bulky breast may be assisted by roentgenographic demonstration of the general contour of deep lesions and visualization of non-palpable lymph nodes.
4. Carbon dioxide insufflation demonstrates encapsulation of fibro-adenomas and fixation of tissues by infiltrating lesions.
5. Cysts can be diagnosed by aspiration and their relations and inner contours demonstrated by injection of gas.
6. Injection of skiodan into discharging lactiferous ducts demonstrates intraductal papillomas, dilated ducts, and collapsible communicating cysts. Intraductal injection of thorotrast is condemned.
7. Biopsy is indicated in all lumps of the breast or axilla in which there is any doubt regarding the benignity of the lesion.
8. Diagnosis should be accurately established by biopsy prior to mastectomy, heavy radiotherapy, or dismissal of a patient as an inoperable case of cancer.

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THE RELATION OF OVARIAN HORMONES TO BENIGN BREAST HYPERPLASIA AND NEOPLASIA[1]

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A GREAT deal of clinical and experimental investigation of the relationship of the ovarian hormones to benign breast neoplasms is being conducted and reported. With these facts in mind, it was decided to analyze our clinical data, with the hope that these relationships would hold for the human breast.

Benign hyperplasia of the breast is a multiform and complex disease, the life history of which may last from several months to more than the entire active life span of the ovaries. The normal breast originates from a group of cells which are, beside other factors, apparently under ovarian hormonal influence. The development of the ducts is influenced by estrin, which is normally present throughout the menstrual cycle in varying amounts (1). The growth of the acini is said to occur under the influence of progestin which is normally present in the latter part of the cycle (2, 3, 4). In animal experimentation it has been shown that progestin probably influences acinar development, but in the human breast evidence indicative of this fact is meager.

The existence of cyclic proliferative and regressive changes in the human breast is far from substantiated. Haagensen (5), in a careful study of human-breast tissue, was unable to find any evidence to support the contention that ducts proliferate during the pre-ovulatory phase (under the influence of estrin), and that acini proliferate in the post-ovulatory phase of the menstrual cycle (under the influence of progestin).

The symptom of pre-menstrual breast engorgement suggests that cyclic changes do occur, and, since they occur at a time when the corpus luteum hormone is most active, it was supposed that the underlying histologic changes would be those of acinar hyperplasia. However, our examination of human breast biopsies, taken pre-menstrually, show no consistency in proliferation of either the acini or ducts with their corresponding young connective tissue mantles. This lack of consistency of findings may be attributed to lack of uniformity of the tissue throughout the breast, lack of regression after pregnancy or other exaggerated physiologic states, adventitious influences such as retained secretion, trauma, nervous or hormonal stimuli, or combinations of these.

Method of Investigation.—This presentation is based upon a study of 60 women who complained of painful breasts, nodular breasts, discharge from the nipple, or a combination of these symptoms. The following order of procedure was maintained whenever possible:

(1) Four consecutive bio-assays of the blood and urine for prolan and estrin; thus a complete hormone study consisted of 16 determinations.

(2) Four weekly endometrial biopsies obtained by means of the Novak suction curette, usually on the same day as the bio-assays were performed.

(3) A biopsy of the breast preferably obtained pre-menstrually.

(4) A therapeutic trial with either hormone or x-ray therapy.

(5) Observation of the patient thereafter at frequent intervals over a period of one to five years.

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Bio-assays.—In many functional endocrine conditions, hormone bio-assays reveal a disturbance in the normal quantitative relationship between the pituitary and ovarian hormones. Our studies suggest that the quantitative levels of the hormone assays individually are not of as great a significance as is the relationship between the two hormones (6, 7). In ovarian failure such as occurs in certain primary amenorrheas and menopause, the relationship is clear-cut and constant; the estrin being absent or low, and the prolan usually very high. However, in the milder functional disturbances such as secondary amenorrheas, pituitary migraine, breast hyperplasias, etc., the status of the endocrine imbalance is not as constant.

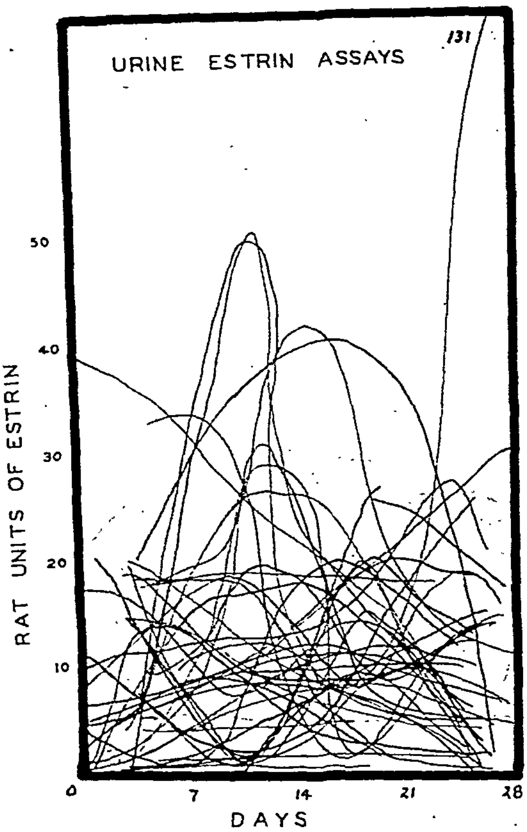

Fig. 1. Composite chart of urine estrin bio-assays of 49 patients. Each curve was constructed on four points representing the bio-assay taken each week during a menstrual cycle. The shaded area represents the normal range. Only one assay was significantly abnormal in that it showed 131 R.U. of estrin per liter. The other three assays of this patient's urine were normal.

The bio-assay may here also show a low or absent estrin content accompanied by a high prolan, but at some later time it may show normal figures or a high estrin level with a correspondingly low prolan. Thus the imbalance may assume a "see-saw" pattern (6).

On 49 of the patients, the following 508 hormonal assays were performed: urine estrin, 180; urine prolan, 165; blood estrin, 105; blood prolan, 58. The complete routine hormone investigation consisted of a blood prolan and blood estrin determination, and a urine prolan (morning specimen) and urine estrin (24-hour specimen) determination performed at weekly intervals for four consecutive weeks. Not all the patients had the entire 16 tests. It is obvious that such a routine study is not always possible or sufficiently comprehensive, but practical limitations dictated the number of assays for each case.

A composite graph was made of the curves representing the urine estrin bio-assays on 49 patients (Fig. 1). The shaded part of the graph represents the range of normal estrin excretion. As a matter of fact, in normal individuals there is found occasionally an excessively high reading. It can be observed in Figure 1 that most of the curves fall within normal range; a few of them are below, and a few are above normal. For convenience of analysis, the curves were divided into six groups as follows:

(1) Subnormal urine estrin assays ranging from 0 to 5 R.U.

(2) Low normal, ranging from 5 to 12 R.U.

(3) Very high urine estrin.

(4) Very high urine prolan.

(5) Those cases showing a marked discrepancy between urine and blood assays.

(6) Cases showing an exaggerated imbalance between estrin and prolan.

There were three patients (Fig. 1) whose urine estrin bio-assays ranged from

0 to 5 R.U. They complained of moderately painful breasts with tender areas, but no definite lumps. All three patients refused to have a breast biopsy performed. In two instances, the pain disappeared spontaneously, and in one of these, the dense induration of the parenchyma softened spontaneously. In the third case, in which both the urine and blood estrin were low, the administration of 1,000 I.U. of estrin (Theelin) twice weekly for nine injections did not affect the symptoms. Even though one case is insufficient for purposes of conclusion, nevertheless if estrin therapy for painful breast engorgement were on a rational basis, one would certainly expect it to be beneficial in those instances in which bio-assay revealed the presence of little or no estrin.

In the second group are five patients whose urine estrin assays were at the lower level of the normal range (5–12 R.U.). Two of these cases had circumscribed lumps of recent origin. This is apparently paradoxical since one should expect in these two cases a higher estrin titer, if there were any relationship between the urine and blood estrin on the one hand, and the recent activity on the part of the pathologic process on the other. Two other cases had painful breasts of longer standing and revealed normal hormone figures. The fifth patient in the group, however, had not only 6, 2, and 8 R.U. of urinary estrin, but also 500, 100, and 0 M.U. of urinary prolan. This high prolan was suggestive of ovarian deficiency (8). This patient (Case 1) is the only one in this group who might be considered to have apparently responded to mild estrin therapy. (See chapter on estrin therapy.) On the whole, there was nothing significant or consistent in this group which exhibited a low normal urinary estrin titer.

There were five cases which revealed a high estrin titer, but in each instance it occurred in only one out of the four weekly assays, the other bio-assays being normal. These unusual reactions were, therefore, considered transitory and atypical and of little biologic significance.

In the group of 11 cases which exhibited very high urinary prolan in one or more assays, no clinical or histologic common denominator was found.

The bio-assays performed on the blood are not analyzed in detail, since they yielded no additional information; in fact, at times they were contradictory to the urinary findings.

To summarize, bio-assays of the blood and urine in cases of benign breast neoplasia or hyperplasia reveal that the titers in most of the patients fall within normal limits. The occasional high or low finding is probably an atypical biologic reaction and has little significance. The assays suggest, therefore, that, in the cases studied, any influence which estrin might exert on the breast is not a function of the quantity of hormone in the blood or urine.

The injection of disproportionately large quantities of the ovarian hormones into small animals will, under certain conditions, produce breast hyperplasia and neoplasia. A parallel exists in the human, when the administration of large doses of estrin to patients with primary amenorrhea or children with gonorrheal vaginitis will produce occasionally a temporary and frequently a permanent growth of the under-developed breast (9, 10).

However, as stated above, these artificially induced changes require on an average of from 30,000 to 100,000 I.U. of estrin a week, whereas the human ovaries produce an average of approximately 1,000 I.U. per week. These conditions, therefore, cannot be considered parallel.

Endometrial Biopsies.—Nine patients had a complete series of four consecutive weekly endometrial biopsies performed. Seven patients had only one endometrial biopsy performed during a known stage of the menstrual cycle—usually pre-menstrually. The secretory change observed in the pre-menstrual biopsy is the only indicator of corpus luteum activity.

One of the cases with a single pre-menstrual biopsy showed irregularities in the

stroma of the endometrium in that it had not progressed to the stage corresponding with the marked secretory activity of the glands. In another case in which there were four endometrial biopsies, some of the glandular elements in the post-menstrual phase still showed slight secretory activity in sporadic glands.

Since the preponderance of the specimens showed no inconsistencies in relation to the menstrual cycle, except for the minor alterations mentioned above, in our material, the endometrium contributed but little information toward the classification or clarification of the disease under discussion.

Clinical Features.—The occurrence of functional menstrual disturbances in women with hyperplasia or benign neoplasia of the breast prompted a study of the menstrual history of the patients in this series. The findings are enumerated in Table I. The fact that half of the patients had normal menstrual histories and that seven others had only transitory menstrual disturbances suggests that the underlying endocrine imbalance which is supposed to be responsible for breast hyperplasia cannot be a profound one.

TABLE I

Number of Cases	Nature of Disturbance	Years' Duration of Each Case
31	Normal menstrual history	
8	Menorrhagia	1, 1, 1, 2, 2, 4, 6, 7
4	Amenorrhea	1/4, 3, 3, 7
3	Oligomenorrhea	1, 1, 1
2	Severe Dysmenorrhea	1, 10
5	Hypomenorrhea	1, 1, 2, 10, 12
7	Past history of irregular menses which was later corrected. Irregularities included all types of functional menstrual disturbances	

Functional menstrual disturbances encountered in this series of patients with benign mastopathy.

The incidence and significance of pre-menstrual breast engorgement were analyzed in our series of cases. Twenty patients had no pre-menstrual breast engorgement; eight had pre-menstrual breast engorgement which had been present throughout their entire menstrual life and which had not changed in character recently, and 32 had pre-menstrual breast engorgement which had been present throughout the entire menstrual life but which had grown more severe recently. In the last group, the median average length of time during which the symptoms of pre-menstrual breast engorgement had been aggravated was two years. In this series, there was no correlation between the type of pre-menstrual breast engorgement and the pathologic process in the breast.

Lactation undoubtedly contributes to the development of mastopathy. It affects the breast not only hormonally, but also mechanically, *i.e.*, stagnation and blockade of ducts by inspissated secretion with subsequent retrograde dilatation. In our series, 29 women were nulliparous and 31 were parous. Of the latter, two had chosen not to lactate, 14 had lactated normally, seven had superabundant milk, and seven had insufficient milk. In this series there was no correlation between the character of lactation and the disease of the breast.

Histologic Study of Breast Biopsies.—There were 45 specimens in this study. In three cases there were two biopsies. We found no uniformly consistent picture which could be correlated with either endometrial studies, hormone bio-assays, clinical picture, or therapeutic responses. In three of the cases, in which histologic study was made of the breast after removal of the ovarian hormone influence by x-ray castration, we still found slight residual epithelial proliferation, persistent cyst, and duct dilatation. (A detailed description of our histologic observations will be the subject of a future paper.)

Estrin Therapy.—Many authors have reported the successful treatment of benign breast hyperplasia and certain forms of neoplasia by the administration of estrin preparations (11, 12, 13, 14, 18). This appears to be a paradoxical type of therapy. Several explanations have been offered for the alleged improvement of breast

pain or disappearance of the lumps. Allen and his co-writers (15), and Gardner and Allen (16) have demonstrated that the injection of estrogenic substances into rodents will cause involutionary changes in their ovaries and probably a decrease in the autogenous estrin production. Others believe that the administration of large doses of estrogenic substances may temporarily restore to normal equilibrium an existing imbalance between the ovary and its related endocrine glands (11).

However, regardless of theory, there exists the contention that estrin is a successful therapeutic agent in these conditions. There also exists an opposing school of thought (17) claiming that the apparent relief of symptoms is only a coincidental remission.

Emge and Murphy (19) state: "These hormones commonly relieve the discomfort of the patient and cysts frequently diminish in size. However, the effect of any female sex or chorionic hormone on cystic breasts is variable and non-predictable. Some breasts will not respond to one but to another, or *vice versa*, and therefore we doubt that the action of either is specific or direct."

Many written and verbal reports pertaining to the beneficial effects of estrin therapy have come to our attention. In most of these instances the therapeutic response has not been established beyond any question of doubt. Our increasing experience with this relatively unstable and unreliable group of patients finally led us to the adoption of a set of suggestions or criteria as a guide in evaluating the response of breast pain and lumps to estrin therapy. (See below.)

There were 17 patients treated with various estrogenic preparations. The dosage varied considerably. The average course of therapy consisted of from eight to twelve intra-muscular injections of 10,000 I.U. of estrin. Of these 17 patients, two showed no response to treatment and three were made worse by it.

A careful analysis of the remaining 12 patients who were apparently benefited by the treatment failed to reveal any case which satisfied our enumerated criteria.

Five patients were discarded from the

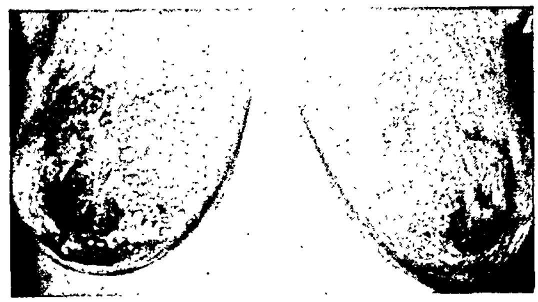

Fig. 2. Case 1. Exquisitely painful breasts requiring morphine for sedation. The breasts contained little fat, and the loose parenchyma dropped to the bottom and was freely movable. This photograph shows the skin erythema following direct breast irradiation. This treatment was followed for the first time by breast discharge and marked aggravation of the pain. (See text for results of estrin therapy.)

list because a final review of the evidence indicated that the benefit resulted either from suggestion or a spontaneous remission. The remaining seven patients would ordinarily be considered as having responded successfully to estrin therapy, except that in each instance one or more elements of doubt existed. Therefore, they too were removed from the list of patients who responded to estrin therapy. The two best instances of apparently successful response to estrin are detailed as follows.

Case 1. On April 1, 1933, a 33-year-old married female came in complaining of pain in both breasts. She had been married 12 years and had nursed each of her four children for more than a year. She always had abundant milk. For the past few years, her menses have been lasting only from two to three days, and the flow has been scant. Her present illness began two years previously with pre-menstrual breast engorgement which gradually grew more severe and finally became continuous. Compresses, supports, etc., failed to ease the pain. Only during the menstrual flow did the pain abate slightly. Examination revealed moderate-sized, pendulous breasts. There was scant fat.

The parenchyma gravitated to the bottom of the breasts and consisted of a cluster of nodules and cords which were exquisitely tender and freely movable. Direct x-ray therapy was given to each breast—1,800 r (measured with scattering). It produced a severe first-degree erythema and was followed by a discharge from both nipples and a marked aggravation of the pain (Fig. 2).

Following this, four weekly urine bio-assays revealed normal estrin, and high prolan, *i.e.*, 500,100, and 0 m.u. The patient was given 1 c.c. ovarian residue intramuscularly three times a week for a total of 24 injections. In addition, during the same time, she was given ovarian residue orally, 5 grains T.I.D. Within two months, the pain had disappeared completely and the patient gained 30 pounds in weight. After one year, the pain recurred. The patient refused a proffered biopsy and never returned.

Although complete abatement of pain and improvement in general health was related sequentially to the ovarian residue therapy, the preparation employed was of such low potency (5–10 m.u. per c.c.) as to raise a strong doubt that the estrin effected the improvement.

Case 2. On Oct. 21, 1935, a 29-year-old white married female was seen, complaining of recurrent painful lumps in both breasts. She had a normal menstrual history. Eight years previously, because of painful nodules in both breasts, a large section of the parenchyma had been removed from each breast. Three years later the pain recurred. Ovarian residue therapy failed, and the operation was repeated. For the past few years her menses have become very profuse and occurred every 22 days. Three months previously, the pain recurred in both breasts and became so severe that she had to walk slowly and for short distances only, because of the discomfort occasioned by the "jouncing." Examination of the breasts revealed the scars of the old operations. The organ was thickened so as to form a tender, "pancake" mass. A chain of exquisitely tender nodules was palpated along the lateral right breast.

For a period of three months the patient was given two injections of 2,000 I.U. theelin and one injection of 10,000 I.U. progynon —B each week, for a total dose of 168,000 I.U. estrin. The pain disappeared for one year and then recurred. At that time a bio-assay (Fig. 3) revealed one blood estrin to be very high and the other three to be normal. Urine estrin was normal, but one of the urine prolan determinations revealed 500 m.u. This paradoxical relationship of the hormones is occasionally observed in endocrine imbalances. It was found in four out of 49 of our patients.

A biopsy of the breast and endometrium was taken pre-menstrually. Microscopic examination of the breast revealed evidence of moderate proliferation of the duct buds. The endometrium revealed a predominantly secretory phase with an occasional residual proliferative gland. The stroma in some areas corresponded to that of a resting phase. The peculiar bio-assay and endometrium pointed to an endocrine imbalance of undetermined nature.

The patient was given three injections of 50,000 I.U. progynon B each; there was no improvement. She was then given emmenin, one teaspoonful T.I.D. for one month, also without improvement. However, gradually over a period of several months the pain abated somewhat and has been fluctuating at a low level since that time.

The response to the first course of estrin therapy was apparently beneficial. However, the erratic behavior of the lesion in response to the second course of therapy introduced an element of doubt.

Gonadotropic Hormone Therapy.—Five patients were treated with antuitrin-S, but no beneficial effect was observed that could be attributed to this method.

SUGGESTIONS FOR EVALUATING HORMONE THERAPY

1. The patient must be observed for several months prior to treatment in order

to establish the validity and character of her signs and symptoms.

2. The patient's statement alone is not sufficient evidence. The physician must detect a specific tender area, generalized fibrosis, lump, or discharge from the nipple.

3. A biopsy should preferably be performed. In our series, several apparently painful fibrous nodules, when exposed, were found to be chiefly adipose tissue, and there was very little evidence in these breasts of any hormone influence on the parenchyma.

4. The estrogenic substance administered must be of known potency.

5. The therapeutic response should be evident soon after institution of treatment. Any delayed improvement occurring months after the injections have been completed cannot be definitely attributed to the hormone therapy.

6. All observations must be made by the same individual or group. These must be frequent and over a period of at least two years. Some of our cases were observed on 60 different occasions extending for periods up to five years, and only a few for less than two years, the minimum period being one year.

RADIATION THERAPY

The sphere of usefulness of radiation in benign breast hyperplasia and neoplasia was explored by administering x-ray therapy directly to the breast (8 cases), to the pituitary gland (11 cases), and to the ovaries (10 cases).

Direct Breast Irradiation.—Eight patients were treated with intermediate or high voltage x-ray therapy given in divided doses directly over the entire breast. The total skin dose ranged from 600 r to 1,800 r (measured with back-scattering) to each breast.

In five patients there was no improvement in the symptoms or lump. In one patient the pain disappeared for five months. However, this same patient was also relieved by estrin therapy, and on several other occasions the recurrent pain or nodularities disappeared spontaneously. In another patient, the pain abated so gradually over a period of months as to suggest coincidence. In one patient, the

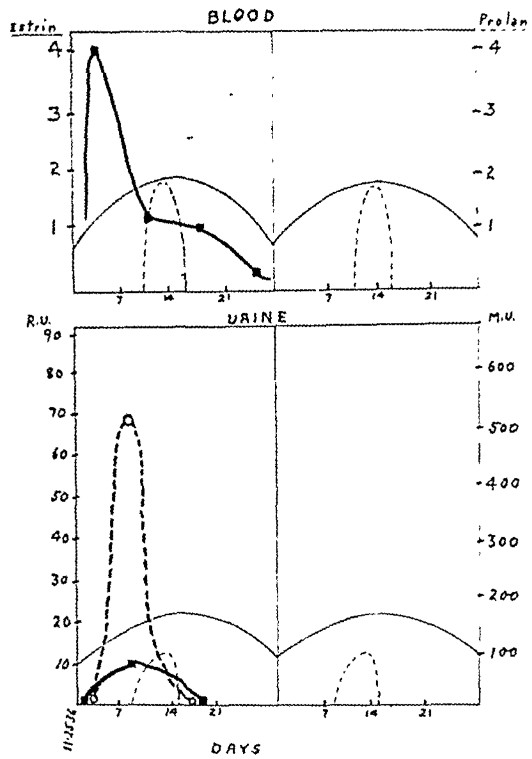

Fig. 3. Bio-assay chart of Case 2. The thin, dotted line represents normal prolan assays; the thin, solid lines, the normal estrin assays. The heavy lines represent the findings in this patient. Note the paradoxical findings: *i.e.*, high blood estrin and shortly thereafter high urine prolan. Such erratic results were found in only four out of 49 of our patients.

pain was definitely aggravated by direct breast x-ray therapy.

In our series of cases, therefore, no beneficial effect was observed which could be attributed without any question of doubt to direct x-ray therapy of the breast. This statement does not imply a denial of the occasional beneficial effect observed by others from this mode of therapy (21, 22).

Pituitary Irradiation.—The pituitary glands of 11 patients were treated with x-rays. Three of these were given small dose (stimulation) x-ray therapy on an empirical basis. There was no effect on the breast condition.

The other eight patients were treated more intensively, receiving a depth dose

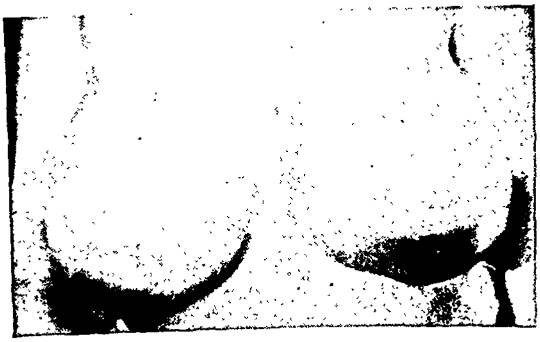

Fig. 4. Case 3. Revealing distortion of breasts and swelling due to a sausage-shaped, cellulitic, inflammatory mass surrounding a duct and its radicles in the medial left breast. Throughout the rest of both breasts were elongated, thickened cords. Pressure on these caused extrusion of slimy, purulent discharge.

of from 1,000 r to 1,800 r (measured with back-scattering) in the pituitary gland itself. The theoretical purpose of this therapy was to reduce the production of the gonadotropic hormones, and thus indirectly, the ovarian hormones. However, this type of treatment also failed to influence the breast pathology to any significant degree. Two patients apparently improved temporarily, but they had also improved at other times following various assorted therapeutic measures, strongly suggesting the potency of psychotherapy. There was no evidence to indicate that the breasts of the group of patients whose bio-assays revealed excessive prolan production, were benefited by intensive irradiation of the pituitary gland.

Irradiation of the Ovaries.—In 12 patients the ovaries were irradiated, four of them being young women. A small dose of x-ray therapy (80 r measured with back-scattering to each ovary) was given to them with the hope of restoring the endocrine imbalance by stimulating the ovary to normal function; all of these attempts failed. There was no change in the breast symptoms or alteration of the menstrual irregularity when present.

The remaining eight cases in this group were castrated by radiation. The ages of these patients varied from 32 to 51 years, with an average age of 43. Our results resemble those reported by Taylor (21), except that the improvement was first noted several months after therapy and progressed slowly and gradually. The effect on the secretions was even slower and less pronounced. There was a fairly consistent subsidence of the symptoms following x-ray castration, but the fact that it required an average time of one year for a maximum beneficial effect to be obtained still leaves room for doubt as to the actual mechanism of this improvement.

One should remember that the cessation of menstruation at menopause or occasionally following the usual radiation castration does *not* necessarily *signify* a *total* disappearance of the ovarian hormones. Therefore, it has been our policy, when employing radiation castration, to double the usual castration dose by administering 800 r (measured with scattering) to each ovary.

Case 3. B. W., a 49-year-old white married female, was first seen on Jan. 8, 1935. She had had normal menstruation up to that date. Her five children were breast-fed for a short time, but insufficient milk had required supplementary feedings. During lactation, she always had trouble with her breasts; they would cake frequently, even on very slight pressure. The present illness began three years previously with bleeding and discharge from the right nipple for ten months. Two years later, breast symptoms recurred in the form of peculiar episodes. At intervals of approximately one month, a large, sausage-shaped mass would form, extending from the nipple up to the base of the breast. This was considered to be due to a secondary infection and cellulitis of a duct and its radicles. The sausage-shaped mass would become red, painful, and hot. After a week, the patient would develop chills and fever, followed by a sudden discharge of quantities of pus from one nipple. The mass would slowly subside, leaving behind a thickened cord. As a result of these repeated attacks and their sequelæ, the patient was in continuous discomfort because of heavy, painful, and tender breasts which interfered with any physical motion.

Examination of the patient revealed both breasts to be enormously hypertrophied, pendulous, engorged, and heavy. Irregular nodular cords could be felt running lengthwise from the nipple upward. These were apparently residual, chronically infected, or old fibrosed duct radicles. Pressure on the ducts would cause extrusion of a thin, greenish-white pus from the nipples. At the time of examination there was one tender, red, hot, sausage-shaped mass along the medial border of the right breast (Fig. 4). A roentgenogram of the breast revealed diffuse, extensive, periductal fibrosis. The left nipple was elevated and inverted. The uterus was enlarged and soft.

On Feb. 21, 1935, a large section of the left breast was removed for histologic study. Grossly, the ducts were filled with a dark green, viscid, slimy substance. The smaller, more distal ducts contained a yellowish secretion. There was considerable dense periductal fibrosis. Microscopically, the breast showed dilated ducts, many of which contained inspissated material. There was an area of adenomatous hyperplasia (Figs. 5 and 6) and, in other areas, proliferation of some of the duct epithelium, giving the impression of early papilloma formation. There were a few areas in which the acini seemed to be actively secreting, while in other areas there was proliferation of duct buds. The periductal connective tissue was dense, and about some of these there were appreciable collections of mononuclear cells, macrophages containing iron pigment, and occasional polymorphonuclear leukocytes. A small pericanalicular fibro-adenoma with areas of calcification was also present.

Four weekly urine bio-assays revealed normal prolan and estrin. In March, 1935, the patient was castrated with x-rays. Gradually, over a period of almost one year, the pain disappeared, the breasts softened, shrank, and the glandular tissue became indistinct. The pain and tenderness disappeared completely, leaving the patient quite comfortable. The discharge also disappeared completely except for one day (Jan. 11, 1938), three years after the castration, when there was a slight, yellow, purulent discharge from the right nipple.

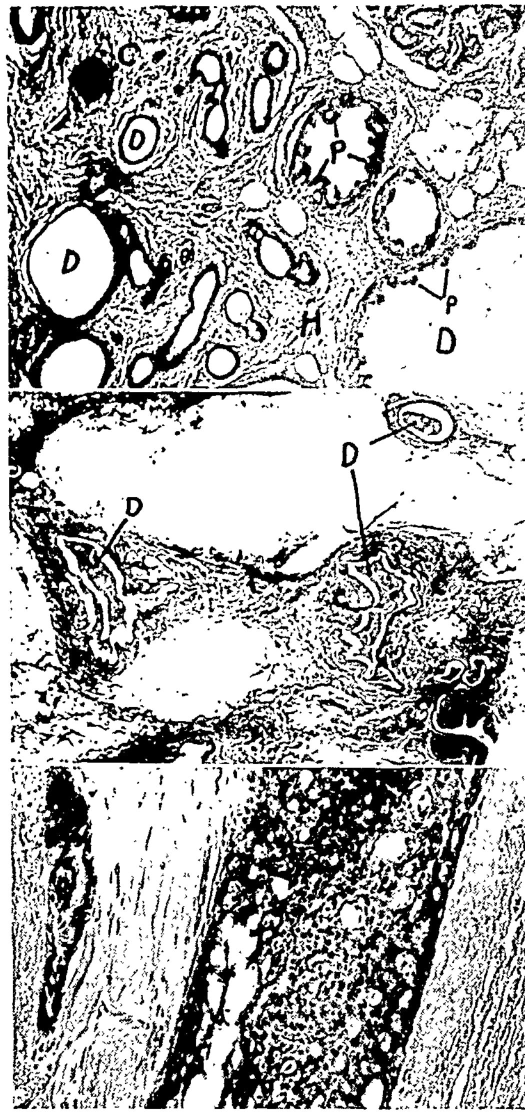

Fig. 5 (*upper*). Case 3. Photomicrograph of section of breast before x-ray castration revealing: (*D*) enlarged, dilated ducts with cyst formation; (*P*) papillary projections of hyperplastic epithelium; (*C*) calcification, and (*H*) dense, hyalinized connective tissue.

Fig. 6 (*center*). Case 3. Photomicrograph of another section of breast before x-ray castration showing distal, outlying, small ducts (*D*). They were filled with inspissated secretion and surrounded by dense hyalinized connective tissue (*C*).

Fig. 7 (*lower*). Case 3. Photomicrograph of section of breast after x-ray castration showing one of the few remaining duct structures in which the epithelium still showed proliferative tendencies. The rest of the breast was mostly adipose tissue.

A second biopsy taken on Jan. 23, 1937,

Fig. 8-*A* (*above*). Case 4. Diagram of lumps before treatment. There was diffuse induration of the parenchyma of both breasts with three relatively circumscribed nodules in each breast. In the lower lateral portion of the right breast, one of these nodules was harder, more circumscribed, and more freely movable than the rest.

Fig. 8-*B* (*below*). Case 4. One year after x-ray castration. The fibrosis and nodules had softened and disappeared with the exception of one nodule which had shrunken only 50 per cent and which proved to be a cyst (cf. Fig. 9).

Fig. 9. Case 4. Photomicrograph of wall of the cyst of the breast removed one year after x-ray castration. It shows some proliferation of the duct buds and some retention of secretion within the ducts. The periductal fibrous tissue is for the most part hyalinized.

two years after the castration, revealed a completely changed picture. This time the breast was composed mostly of fat. The residual ducts were small and little secretion was left in them. The previous dense induration had also softened and disappeared to a great extent. Microscopic examination revealed mostly adipose tissue with a rare duct structure in which the epithelium showed slight proliferative tendencies (Fig. 7).

Comment.—This is a case in which the pathologic process subsided over a period of one year after institution of x-ray castration. The effect on the breast was confirmed by biopsies taken before and after treatment.

Case 4. R. L., a 48-year-old white female, had a normal past menstrual history and one child, who had been breast-fed for nine months. Two years previously the intermenstrual interval became irregular, ranging from 21 to 39 days. Her usual mild three-day pre-menstrual breast engorgement was not disturbed. Her present illness commenced three years ago with lumps in both breasts pre-menstrually. These disappeared but recurred six months later. They have persisted but fluctuated in size, being larger and more tender pre-menstrually. Examination revealed well-developed and well-rounded breasts. The parenchyma was diffusely fibrosed, and in each breast were three nodules of different sizes, more or less circumscribed. The nodule in the lateral lower portion of the right breast was more rounded, firmer, and more solid than all the others and quite freely movable (Fig. 8-*A*).

Following x-ray castration, the nodules disappeared within a period of two months with the exception of the above-mentioned particular nodule in the lateral right breast, which had only shrunken 50 per cent one year later (Fig. 8-*B*). This was excised and found to be a cyst. The breast tissue about the cyst wall showed proliferation of duct buds and some retention of secretion within the ducts. The periductal fibrous tissue was, for the most part, hyalinized (Fig. 9).

CONCLUSIONS

1. Bio-assays of the blood and urine in cases of benign breast neoplasia and hyperplasia reveal that the titers of most of the patients fall within normal limits. It is, therefore, probable that any influence which estrin might exert on the breast is not essentially a function of the quantity of the hormone in the blood or urine.

2. Endometrial biopsies contribute but little information toward this disease.

3. Histologic studies of breast biopsies taken at a specific time during the menstrual cycle show no consistent pattern which could be correlated with either endometrial studies, hormone bio-assays, clinical picture, or therapeutic responses.

4. Because of the absence of detectable manifestations of endocrine irregularities, the rôle of the ovarian hormones in the development of various benign abnormal processes in the breast is still undetermined.

5. The rationale of estrin therapy is not clearly understood. Its effectiveness is yet to be proved beyond any question of doubt. We have outlined a list of suggestions to assist in obtaining a more accurate evaluation of estrin therapy.

6. Antuitrin-S was found to have no therapeutic value in our cases.

7. Direct breast irradiation was of no value in eight patients so treated.

8. X-ray stimulation of the pituitary gland, or the ovary, or both was found to be of no value.

9. X-ray castration is apparently promising but the results are not clear-cut. It frequently requires one year after castration to obtain a maximum therapeutic effect. It is recommended that a larger than usual castration dose be employed, *i.e.*, a depth dose of 800 r (measured with scattering) to each ovary, in order to destroy the more resistant follicles.

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CARCINOMA OF THE BREAST, WITH CONSIDERATION OF WHOLE ORGAN SECTION STUDIES[1]

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THERE are two principal methods of study of neoplasia: (*a*) comparative study and animal experimentation, and (*b*) pathologic anatomy studies and analysis of results of treatment in the actual patients. Both methods are important, and neither should be neglected. In this connection, it is interesting to consider how difficult it is for us to keep two methods of study on an equal basis. In the days of gross pathologic anatomy, it was difficult for some men to grasp the importance of the new method of study of cells. Then the pendulum swung so far that no one was paying any attention to gross pathology, but concentrating on cellular pathology; only rather recently have we come to a proper balance of the two methods. Then, with the development of experimental pathology, biochemistry, and similar methods of study, there may have been some tendency to pay

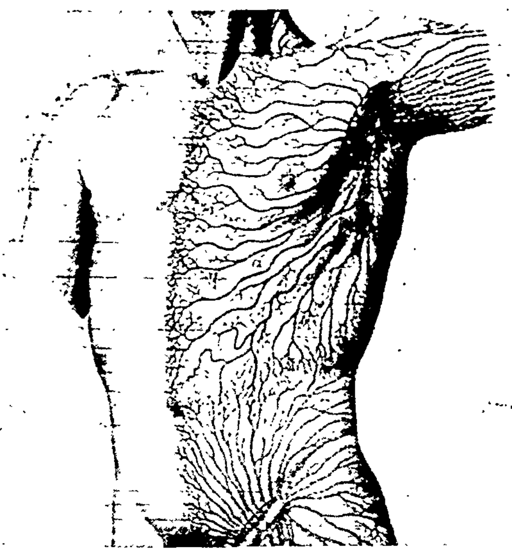
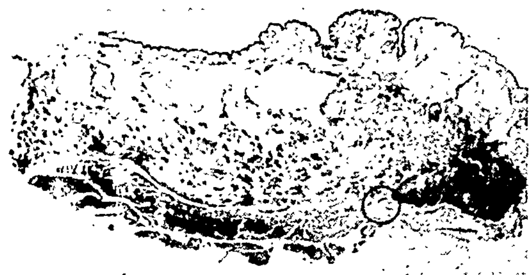


Fig. 1. From a plate in Sappey's "Vaisseaux Lymphatiques," showing the lymphatic plexus (fascial lymphatic plexus), which lies in the deepest layers of the subcutaneous fat and forms the main highway for permeation in breast cancer. Numerous trunks are seen arising from the plexus and passing to the axillary or the inguinal glands. Along these trunks embolic invasion of the axillary glands occurs, the trunks themselves escaping permeation until a late stage. The fine meshwork of vessels constituting the fascial plexus is only partially indicated in this figure, so that the trunk lymphatics are made to appear unduly prominent (Handley).



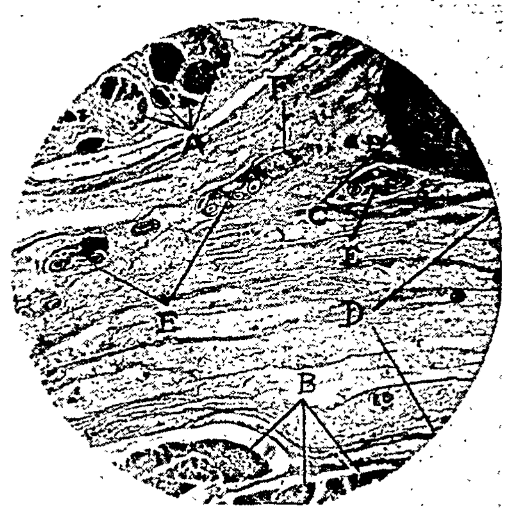


Fig. 2 (*above*). The pectoral fascia is shown, lying on the pectoral muscle. A carcinoma of the breast extends down to the fascia on the right.
Fig. 2-*A* (*below*). Photomicrograph of the ringed area shown in Figure 2. *A*, lobules of the breast; *B*, pectoral muscle; *C*, carcinoma; *D*, pectoral fascia; *E*, fascial plexus with lymphatics filled with epithelial cells, with fibrosis at *F*.

[1] Presented before the Twenty-fourth Annual Meeting of the Radiological Society of North America, at Pittsburgh, Nov. 28–Dec. 2, 1938.

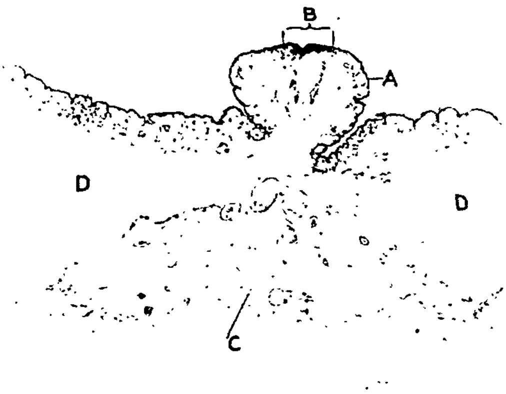


Fig. 3.

Fig. 4.

Fig. 3. Photograph of a whole microscopic section of the breast of a female, married, aged 52 years. *A*, the nipple. Between the lines below *B* there is a surface lesion which gave rise to the diagnosis of Paget's disease of the nipple. The lesion was bright red and covered by small white scales; the edges were hard. *D*, subcutaneous fat. At *C* there is highly malignant-looking epithelial neoplasia in a terminal duct and its acini. The elastica of this breast, if present, stained badly; the elastica of the blood vessels stained normally. The breast is in an atrophied state. The ducts and their acini in many parts contained epithelium in a state of desquamative cystiphorous hyperplasia. The axillary lymphatic glands contained no carcinoma and the patient is alive and well 18 years after the operation. A remarkable feature of this specimen is the enormously hypertrophied state of a multitude of sebaceous glands that existed in the epidermis of the nipple and the areola. The amount of sebaceous glands in this instance appears to be too great to be explained as being a degree of normal variation. The condition could be described as being one of sebaceous adenomatosis (Cheatle and Cutler).

Fig. 4. Chronic cystic mastitis. There are small cysts, and there is granular material in the ducts.

less attention to pathologic anatomy studies, gross and microscopic, of material from the human cases. Handley pointed out the difficulties in keeping the two methods of study on an equal basis; and, in the preface to the second edition of his book, he says: "Attempts have been made to exalt comparative and experimental research at the expense of the equally new developments of microscopic

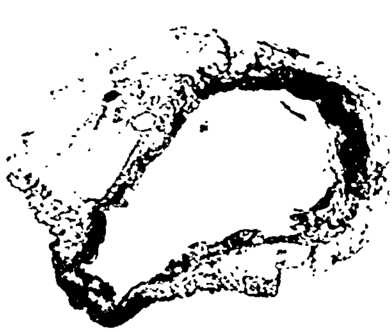


Fig. 5. Benign tumor becoming malignant, showing skin, nipple, and "blue dome" cyst. The entire thickened wall is the seat of extensive carcinomatous growth (Wainwright).

research." He welcomes the statement of Bashford, a protagonist of the experimental school, that "the methods of pathologic anatomy may too rashly be held to be bankrupt."

The principle of evaluation of the degree of anaplasia in terms of grades of malignancy has been a factor in sustaining interest in pathologic anatomy studies. Handley sought to revive pathologic anatomy studies by extension of methods, so that, instead of a "cheese testing," it would show the extension of the lesion; that is, pathologic physiology—living pathology—showing the disease as a process, not static. In applying his idea for the application of microscopic studies on a macroscopic scale, a co-ordination of the minute and naked eye morbid anatomy, he cut strips of tissue, radiating from the edge of the primary tumor; cut these strips into marked blocks; cut and stained sections from these blocks, and thus had micro-sections of the whole length of the original strip.

Whole organ sections, as developed by Fraser, Cheatle and Cutler, Wainwright,

Fig. 6.

Fig. 7.

Fig. 8.

Fig. 6. Benign tumor becoming malignant, showing skin and a carcinoma below. The reproduction does not show the condition well, but close inspection shows that the center is more lightly stained and less "rough." This central core is a typical intracanalicular fibroma, which is undoubtedly the origin of the carcinoma (Wainwright).

Fig. 7. Stasis and dilated ducts showing skin, nipple, duct cone, and breast, with a carcinoma under the arrow. There are numerous dilated ducts leading down to the carcinoma, some in the malignant tissue (Wainwright).

Fig. 8. Stasis and dilated ducts showing skin, nipple, duct cone, and breast, with a carcinoma under the arrows. Numerous dilated ducts leading down to the carcinoma, some in the malignant tissue (Wainwright).

and the writer, apply Handley's idea in a very efficient and practical manner.

The very essence of malignancy is its tendency to *dissemination;* (*a*) local extension, and (*b*) the formation of secondary tumors at a distance, this latter being known as metastasis.

As Handley has stressed, we must visualize malignancy as a process, not static; which means we are not to consider carcinoma of the breast as a local tumor, but must consider the *process of its dissemination.* If carcinoma of the breast were localized in, and limited to, the breast tissue, it would be of little more importance than is fibro-adenoma of the breast. It is the dissemination of carcinoma of the breast—as of malignancy anywhere—that makes it so formidable.

So, with our whole organ sections, we go beyond the mere consideration of the primary carcinoma of the breast, and consider the *process of its dissemination,* this being the important consideration.

Carcinoma of the breast is disseminated by: (1) infiltration of the tissues locally; (2) permeation in the lymphatics leading from the tumor, and (3) lymphatic embolism to the axillary lymph nodes. Since carcinoma of the breast is disseminated by way of the lymphatics, it is necessary to consider the lymphatic drainage of the breast. The lymphatics of the breast lead directly down to the lymphatic plexus on the pectoral fascia, and through this

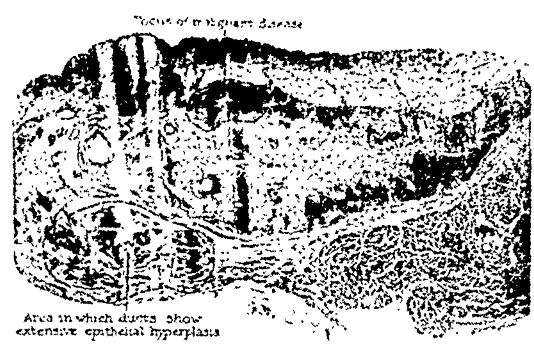
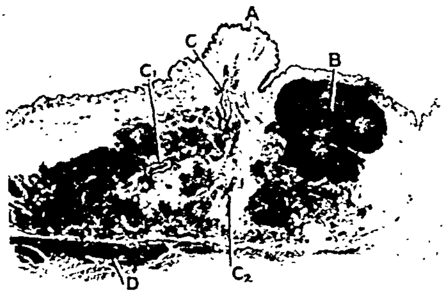


Fig. 9 (*upper*). The development of duct epithelial hyperplasia adjacent to a focus of malignant disease (Fraser).

Fig. 10 (*center*). Solid carcinoma in the breast, entirely away from the nipple. Marked stasis in the ducts beneath the nipple.

Fig. 11 (*lower*). Marked epithelial hyperplasia, with duct stasis. An area of carcinoma is indicated by *A*.



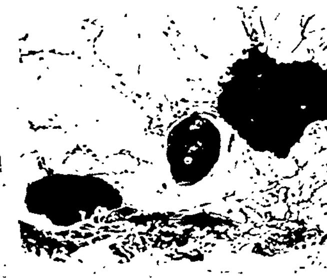


Fig. 12. Fig. 13. Fig. 14.

Fig. 12. Photograph of a whole microscopic section of the breast of a female, married, aged 56 years. *A*, nipple; *B*, mass of carcinoma; *C*, C_1, C_2, branches of a duct distributed to the opposite side of the breast, from which carcinoma cells have escaped; *D*, pectoralis major. The lump *B* had been noticed for six months. The rest of the breast felt normal on palpation. Discharge of blood from the nipple had not occurred. The lymphatic glands in the axilla were heavily involved in the carcinoma process. The normal parts of the breast in which *B* is situated are so infiltrated with carcinoma that most of them have been destroyed and it is impossible to state whether or not they contained epithelial neoplasia. In some of the peripheral parts, however, there are terminal ducts containing malignant-looking epithelial neoplasia that is still confined within normal boundaries. It is highly probable that the whole of two ducts in this specimen contained epithelial neoplasia from which carcinoma arose (Cheatle and Cutler).

Fig. 13. Multiple tumors showing skin, nipple, and breast with two carcinomatous nodules (Wainwright).

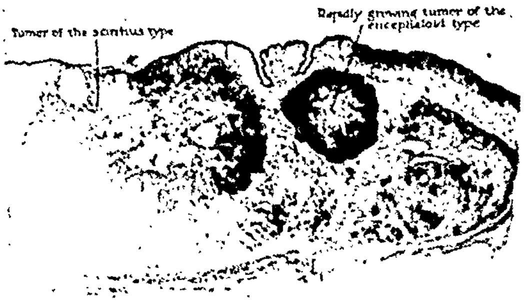
Fig. 14. Multiple tumors showing breast, underlying muscle, and three separate carcinomatous nodules, the lower involving muscle (Wainwright).

TABLE I.—DERIVED FROM 422 CASES OF BREAST CANCER, SHOWING IN WHAT NUMBER OF INSTANCES, EITHER WITH OR WITHOUT OTHER METASTASES, A SINGLE ABDOMINAL ORGAN OR PAIR OF ORGANS, WAS AFFECTED BY CANCER (HANDLEY)

		Guy's Cases	Middlesex Cases	Total
Viscera Covered by Peritoneum	Liver	13	77	90
	Portal glands	1	1	2
	Ovaries	1	2	3
	Uterus	0	1	1
	Pelvic peritoneum	0	1	1
	Peritoneum	0	4	4
	Mesentery	1	1	2
	Intestine	1	0	1
	Spleen	0	1	1
Retroperitoneal Viscera	Right kidney	0	4	4
	Left kidney	0	1	1
	Both kidneys	0	1	1
	Right adrenal	0	1(?)	1(?)
	Lumbar gland	0	1	1
	Lumbar vertebra	0	2	2
		17	98	115
		Out of 93 cases = 18%	Out of 329 cases = 29%	Out of 422 cases = 27%

TABLE II.—SHOWING INFECTION PERCENTAGES OF THORAX AND ABDOMEN IN EARLY (GUY'S HOSPITAL) AND LATE (MIDDLESEX HOSPITAL) SET OF CASES (HANDLEY)

	Guy's Hospital (early cases)	Middlesex Hospital (late cases)
Metastases present in abdomen and not in thorax (Abdominal Group)	17 per cent	11 per cent
Growth in thorax and not in abdomen (Thoracic Group)	10 "	22 "
Metastases present in both thorax and abdomen (Abdomino-thoracic Group)	20 "	35 "
No metastases present (except in axillary glands)	40 "	23 "
Other cases (*e.g.*, bone infection)	13 "	9 "



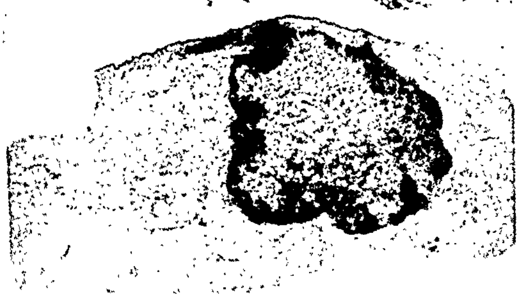
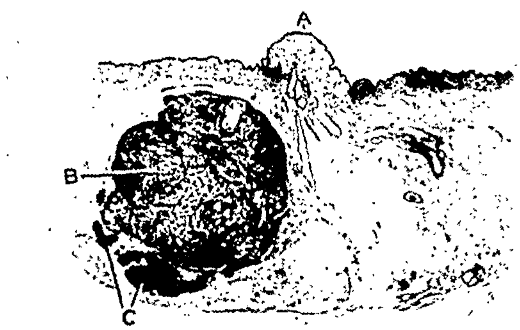


Fig. 15 (*upper*). To illustrate the fact that various types of tumor formation may occur in the same breast (Fraser).

Fig. 16 (*center*). Two types of carcinoma in the same breast: *A*, comedo carcinoma; *B*, solid glandular type with extensive necrosis.

Fig. 17 (*lower*). Extensive tumor formation, yet showing wonderful localization (Fraser).



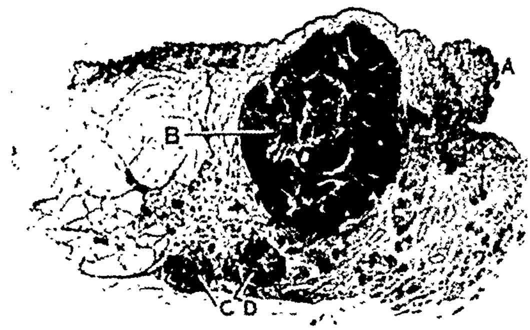


Fig. 18 (*above*). Photograph of a whole microscopic section of the breast of a female, married, 52 years of age. *A*, the nipple. *B*, a large duct carcinoma from which carcinoma cells are invading the supporting connective tissue of the breast at *C*. These invading cells were not columnar in shape: some were spheroidal, others cuboidal, and others hexagonal in shape. Microscopic examination of the axillary contents did not reveal the presence of carcinoma. The tumor was freely movable beneath the skin. The process of preparation has made the tumor appear nearer the skin than it really was on palpation (Cheatle and Cutler).

Fig. 19 (*below*). Photograph of a whole microscopic section of the breast of a female, married, aged 54 years. This breast affords an example of a primary epithelial neoplasia affecting the whole of a duct, its branches, and acini from which carcinoma cells have escaped from three separate parts of its distribution, namely, *B*, *C*, and *D*. *A*, the nipple. The tumor, *B*, is infiltrating the surrounding tissues at many parts of its circumference. There is malignant-looking epithelial neoplasia in all the branches of this duct and their acini. There is a marked hyperplasia elastica in all the ducts of this breast, but it is more marked in those containing the malignant-looking epithelial neoplasia. The axillary lymphatic glands contained carcinoma. The patient died within five years of the operation (Cheatle and Cutler).

plexus to the axillary lymph nodes. Tributaries from this plexus extend through the chest wall to lymph nodes beneath the pleura. This plexus also connects with the abdominal lymphatics through the epigastric angle, and so to the abdominal organs, especially the liver (Fig. 1).[2] The pectoral fascia is well shown in Figure 2, with a carcinoma of the breast extending down to it on the left.

1. We may first look at the situation regarding the primary tumor in the breast, as shown by whole organ sections. Cheatle and Cutler give a general view of the whole organ section of the breast (Fig. 3); Whitmore shows chronic cystic mastitis, or parenchymatous hyperplasia (Fig. 4);

[2] As indicated in each instance, certain illustrations are from the authors cited, as follows: Cheatle and Cutler, Figs. 3, 12, 18, 19, and 22; Ewing, Fig. 37; Fraser, Figs. 9, 15, 17, 29, 30, 31, and 32; Handley, Fig. 1, and Tables I and II; MacCallum, Fig. 35, and Wainwright, Figs. 5, 6, 7, 8, 13, 14, 20, 21, 33, and 34. My thanks are extended to the respective authors and publishers for permission to use the figures noted: the specific references are listed at the end of this paper.

Fig. 20.

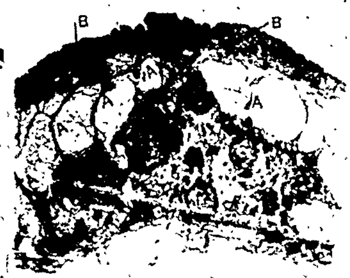


Fig. 21.

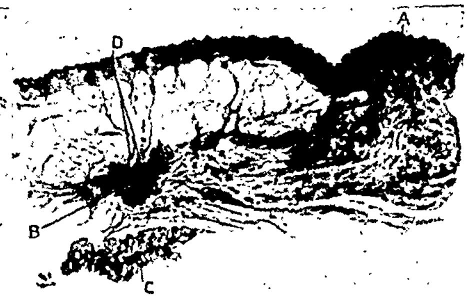


Fig. 22.

Fig. 20. Spread by connective tissue septa, showing skin, tumor, and muscle. Connective tissue septa with many nodules (*A*, *A*, *A*, etc.) formed by escaping carcinomatous cells (Wainwright).

Fig. 21. Spread by connective tissue septa, showing skin, nipple, and breast, almost completely filled with carcinomatous growth. At *A*, *A*, *A*, etc., are septa distended with escaping carcinomatous cells. At *B*, *B* are subcutaneous nodules formed from cells brought up by nearby septa (Wainwright).

Fig. 22. Drawing of the breast (× 2) of a female, married, aged 48 years. *A*, nipple; *B*, carcinoma. The primary epithelial neoplasia from which it originated is situated only in terminal ducts and their acini. *C*, pectoralis major; *D*, ligamenta suspensoria containing carcinoma. Only one axillary lymphatic gland contained carcinoma cells and that was situated near the breast and behind the anterior fold of the axilla. The patient is alive and well 15 years after the operation (Cheatle and Cutler).

while Wainwright shows the transition from benign to malignant tumors (Figs. 5 and 6). Duct stasis and epithelial change adjacent to the tumor are shown by Wainwright (Figs. 7 and 8); Fraser (Fig. 9); Whitmore (Figs. 10 and 11), while Cheatle and Cutler show carcinoma cells in the ducts adjacent to the tumor (Fig. 12).

More than one tumor in the breast is shown by Wainwright (Figs. 13 and 14); Fraser (Fig. 15), and by Whitmore (Fig. 16). Sharp localization of the tumor is shown by Fraser (Fig. 17).

Infiltration of the breast tissue with cancer cells is very well shown by whole organ sections: Cheatle and Cutler (Figs. 18, 19, and 22); Wainwright (Figs. 20 and 21), and Whitmore (Figs. 23, 24, 25, and 26). The extensive and intensive infiltration of the breast tissue in inflammatory carcinoma is well shown by Whitmore (Fig. 27).

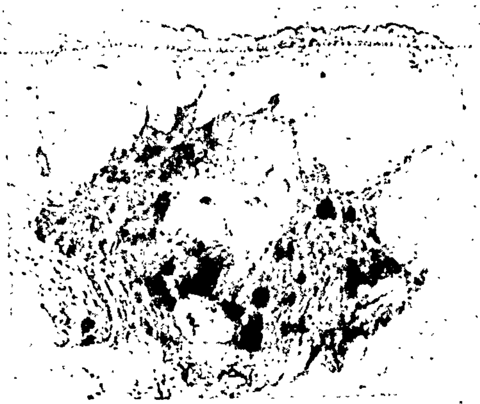
2. Infiltration of the breast tissue and permeation in the lymphatics of the fascial plexus, where the lymphatics accompanying the blood vessels are filled with masses of tumor cells, is shown by the writer in Figure 28.

Permeation is shown by Fraser (Fig. 29); with blocked lymphatics and secondary lymphatic spread by Fraser (Fig. 30), and extension upward to the skin by Fraser (Fig. 31), and by Whitmore (Fig. 28) with tumor cells infiltrating the epidermis. The route of extension downward through the breast, to the fascial plexus, is well shown by Fraser (Fig. 32); while Wainwright shows the extension through the tributaries spreading through the pectoral muscle to the lymph nodes beneath the parietal pleura (Figs. 33 and 34). Extension through the pleura and through the lymphatics of the lung is shown by MacCallum (Fig. 35).

One of our cases (Fig. 36) may be cited here. A 70-year-old white woman with a lump in the breast was given a course of x-ray irradiation, followed by a simple mastectomy; one year later there was an axillary node, one centimeter in diameter, on that side; and she died two years later with pulmonary metastases.

Lymphatic embolism to the axillary nodes is shown by Ewing (Fig. 37) in the case of a woman with a carcinoma of the breast, who was roughly handled in examination.

3. Handley stressed the importance of the connections of the fascial plexus with the abdominal lymphatics in explaining metastasis to the abdominal organs in carcinoma of the breast, which is not so uncommon as one might expect (Tables I and II). The extension is through the epigastric angle to the lymphatics beneath the peritoneum, and across the peritoneum



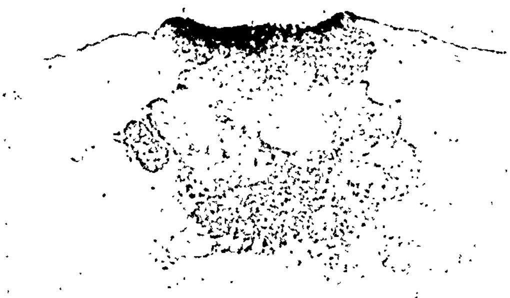


Fig. 23 (*upper*). Infiltration of the connective tissue septa with carcinoma cells extending along the lymphatics.
Fig. 24 (*center*). Infiltration of the connective tissue septa with carcinoma cells extending along the lymphatics.
Fig. 25 (*lower*). Infiltration of the connective tissue septa with carcinoma cells extending along the lymphatics.

to the abdominal organs, just as across the pleura to the lungs. Extension to the liver is quite a frequent occurrence, the extension being along the falciform ligament which is attached to the posterior sheath of the rectus abdominis, one inch to the right of the median line. In Handley's study of 53 cases with metastases to the abdominal organs, the liver alone was

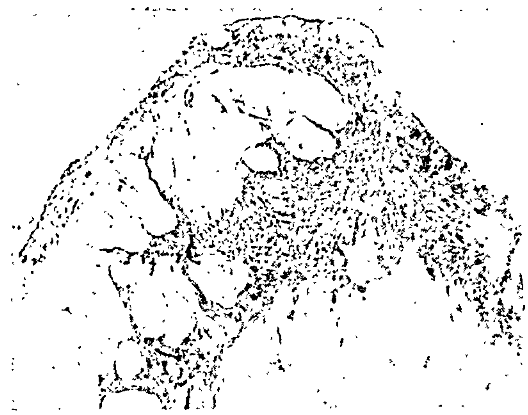


Fig. 26 (*above*). Infiltration of the connective tissue septa with carcinoma cells extending along the lymphatics.
Fig. 27 (*below*). Extensive and intensive infiltration of the breast tissue with carcinoma cells in inflammatory carcinoma.

involved in 36 cases. The writer's case of carcinoma of the breast, with extension to the skin of the breast (Fig. 28), shows extension to the liver, and to no other abdominal organ; the extension being through the connection of the blocked lymphatics of the fascial plexus to the abdominal lymphatics, and through the lymphatics in the falciform ligament to the liver, which is filled with metastases (Fig. 38). There were no metastases in the axillary nodes at autopsy. In this case, x-ray examination showed a shadow in the lung which proved at autopsy to be an area of consolidation and necrosis (Fig. 39), with no giant cells or other structure of tubercle in the nodule, and no indication of tumor cells.

DISCUSSION

1. We see the importance of pathologic anatomy studies, especially by whole organ

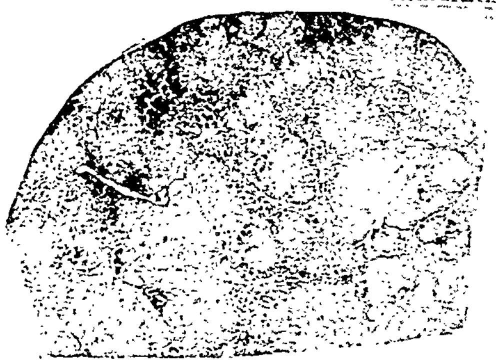


Fig. 37 (*upper*). Multiple recent tumor-cell emboli in the sinuses of an axillary lymph node. From a case of mammary carcinoma which had been roughly manipulated before operation (Ewing).

Fig. 38 (*center*). Metastases in the liver in a case of carcinoma of the right breast. The breast section is shown in Figure 28.

Fig. 39 (*lower*). Area of necrosis in the lung of a case of mammary carcinoma with metastasis to the liver, but no metastases in the axillary nodes at autopsy. The breast is shown in Figure 28; the liver in Figure 38.

there. From this point, tumor-cell emboli go to the axillary nodes, and we see how undue manipulation of the breast in examination may produce tumor-cell emboli in these nodes.

At a recent meeting, one speaker told of having seen cases of carcinoma of the breast in which the breasts were actually sore from the rough handling during examination. Since dissemination is through the fascial plexus, one wonders if more damage may not be done by rough handling in examination than by surgical biopsy—which we are so careful to avoid to-day. This is something to think about.

7. Extension down through the chest wall and across the pleura is probably not the usual route of extension to the lung in carcinoma of the breast, but it is pointed out by Handley, and it fits with the clinical experience that, in recurrence after radical operation for carcinoma of the breast, it not infrequently develops as a pleurisy with effusion, which means extension to the lymph nodes beneath the parietal pleura and through the pleura.

8. These studies show the importance of the connections between the lymphatics of the fascial plexus and the abdominal lymphatics as the route of dissemination of carcinoma of the breast to the abdominal organs, and especially to the liver. Through all of these studies we see the importance of removing the fascial plexus in carcinoma of the breast.

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DISCUSSION ON SYMPOSIUM ON CARCINOMA OF THE BREAST

Chairman Rollin H. Stevens, M.D. (Detroit): In arranging this Symposium we had in mind an attempt (in the al-

together too short a time at our disposal) to convene in one group workers in the biochemistry, physiology, and anatomy of the normal and pathologic human breast, to the end that a better co-ordinated approach to the indicated therapy of mammary cancer might be made and better understood.

The literature is filled to overflowing with statistical articles on surgical and radiation therapy, both of which are as yet not based on factual data.

Experimental studies of the mammary gland in laboratory animals is much in advance of the actual clinical aspect. The laboratory has produced a wealth of fairly precise and accurate information concerning the breasts of lower animals. This information probably applies only in small part to the human breast, because the anatomy, physiology, and biochemistry vary in different races and families of animals.

Perhaps there is also variation in human races and even in lesser degree in families and individuals. As an example, experiments on mice show that the injection of estrin in large quantities is followed by carcinoma of the breast, but this is limited almost, if not entirely, to strains of mice with hereditary tendency to cancer.

Just here I should like to pay a tribute to Maud Slye. In spite of the many criticisms of her work in heredity the world owes her an everlasting debt of gratitude for her years of exhaustive pioneering research on heredity of cancer in mice, which is fundamental in carcinogenic studies.

Hospitals, generally, are pretty much like hotels: beyond supplying board, room, and nursing, they are doing but little to prevent and alleviate the suffering from cancer.

We, as surgeons and radiologists, are spending too much time in contributing statistics that lack in precision and are based upon inaccurate data, so that the statistics are of little, if any, value.

We must have—and the public should demand—more clinical research in hospitals. Many thousands of cancer victims suffer and die each year, martyrs to this lack of foresight of the hospital in providing proper personnel and equipment for the scientific study of the vast amount of clinical material passing through its wards.

The work of the participants in this Symposium in studying, by more scientific methods, the phenomena taking place in the normal and pathologic human breast should be a stimulus to every one of us to endeavor, from now on, to make more and more precise and accurate observations on every cancer of the breast we are called upon to treat.

LEWIS G. JACOBS, JR., M.D. (Winona, Minn.): I would like to comment on the fact that not only in this Symposium today, but in the literature in general, statistics are gathered and nothing is done with them. It is a common thing to see a set of figures put down—and then forgotten. I think that to do so is a serious mistake in our analysis of cancer statistics, because if we do not study the figures we get, we can derive no good from them.

In Dr. Adair's[3] figures you will remember the result in five years for one group and four years for another group, and while those facts are certainly important, I think it equally important that the behavior of his patients in the interim, that is, at one year, two years, three years, should be studied. It is well known, I think, that cancer of the breast shows no evidence of leveling off; patients still die after ten years or more. If we talk of five-year cures of cancer in the breast, it is silly. If we do not make more thorough attempts to analyze statistics, I do not think we are getting the most benefit from them.

There have been quite a lot of books written on statistics and methods, not all applicable to cancer statistics. Some methods give a great deal of information, particularly those that have to do with the studying of the reliability of any given

[3] Dr. Adair's paper has not been received for publication.

example, and I think until we start applying what we can learn about statistics to the statistics we gather, it is essentially a waste of time to gather them at all.

Dr. Rhinehart, M.D. (Little Rock, Arkansas): What a lot of us came for—and I wish to speak for that group—is to ask a question and I will ask it of all the essayists in the Symposium: Shall we or shall we not attempt to castrate these patients who have carcinoma of the breast? We came here to find that out, and I will leave the question up to anybody who wants to answer it.

Wright Clarkson, M.D. (Petersburg, Va.): No doubt, all of us have been surprised to see the large number of carcinomas associated with chronic cystic mastitis shown here to-day by Dr. Whitmore.

For many years we considered every lump found in a woman's breast to be cancer until it had been proven to be otherwise. As we learned more about the gross pathology of tumors of the breast we began to follow the teachings of Bloodgood and others and to look upon those cases with definite clinical signs of chronic cystic mastitis as benign, and to treat them accordingly. Going on this assumption, I made some gross errors, for some of these cases developed carcinoma.

To-day, I am inclined to return to our former attitude toward lumps in the breast. I now look with suspicion even upon cases with typical chronic cystic mastitis and no clinical evidence of malignancy.

May I ask the question: In what percentage of chronic cystic mastitis cases, with no clinical evidence of malignancy, would we expect to find cancer if the entire breast was sectioned in every case in the manner demonstrated by Dr. Whitmore?

Eugene R. Whitmore, M.D. (*closing*): If the doctor who spoke about the statistics will come to our exhibit booth, we will show him a follow-through which did not stop at five years, but a ten-year follow-up on cases of breast cancer, all in one hospital.

Incidentally, we have started an Honor Roll on breast cancer, the basis for being on which is that a woman has lived beyond her normal expectancy of life at the time of operation. As you know, at any age, every one of us has a certain expectancy of life. Thus, a woman who is operated on at 45 years of age and remains alive and well beyond her expectancy (61.1 years of age) is the type of case on which we have developed the Honor Roll.

One of the doctors said these whole organ sections were good for teaching undergraduates. They are; but I do not think the graduates are hopeless: I think they can learn, too. I believe that if we do more for the undergraduates, as well as for the graduates, along this line, we will not have the difficulties of which we see so many. Thus, there is one question that comes up: how many of us would advise radical operation following preoperative irradiation, and how many of us would advise simple mastectomy; and why, in each case? It is just such work as we are presenting here to-day—on which we have an abundance of material—that will enable us to answer that question, and you realize that the undergraduates who are coming along now, will know this when they get out in practice. We have a course in oncology in our senior year, and it is well worthwhile. These young men learn a lot about it, and they will soon be the graduates. I have learned a lot about it myself, and I have been a graduate for quite a while.

As to the question on cystic mastitis. Of course, you realize that the material I have shown to-day is from a selected group of cases, in which we are dealing with carcinoma associated with cystic mastitis. I think we encounter carcinoma in breasts with cystic mastitis just as frequently as in breasts without cystic mastitis; that is, the cystic mastitis has little to do with carcinoma of the breast, one way or the other. In Cheatle and Cutler's figures, 20 per cent of the cases of carci-

noma of the breast were in breasts with cystic mastitis: that sounds pretty high; but, when we consider that about one-third of the women over 40 years old have cystic mastitis, then, on Cheatle and Cutler's figures, instead of an increased incidence of cancer in breasts with cystic mastitis, it would indicate a decrease in incidence. I am sure that we find carcinoma in a breast with cystic mastitis frequently; as the case I showed, in which the woman had pre-operative irradiation and a simple mastectomy. A year or so later she developed a carcinoma in the other breast—a breast with cystic mastitis. I think carcinoma occurs just as frequently in women with cystic mastitis as in women without cystic mastitis. Is there any predisposition to carcinoma in cystic mastitis? I do not see that there is, though there may be—that is merely my opinion.

CHAIRMAN STEVENS: I now have a few questions which have been turned in, and I will ask them of Dr. Adair. Someone, who did not sign his name, wants to know: How long an interval of time should there be between pre-operative therapy and surgery? What size ports and daily doses?

FRANK E. ADAIR, M.D. (New York City): Our technics have varied, and they will continue to vary according to the size of the patient, so that it is impossible to answer the question as to the exact size of the ports. The duration of pre-operative radiation will continue from three to six weeks, depending on whether you are giving 1,200 r to the port or whether you are giving 3,000 r per port. Our technic is that we ordinarily give 300 r over each of two ports daily until the total amount designated is delivered. We use five ports. We use the medial and lateral breast ports. We use an axilla direct, and one through the back toward the front also—the supraclavicular port. That is our routine. It takes any time from three to six weeks to deliver this dosage, and after it is delivered we ordinarily wait from six to eight weeks before we do the radical amputation, because it takes about that duration of time for the radiation effects to take place in the tissues.

It is fairly well understood that the better known operating groups in America have pretty much the same five-year results in cancer of the breast. So we have that base line, which has obtained for many years. This result is 75 per cent if the cancer is confined to the breast, if it is also in the axilla, from 20 to 23 per cent.

Concerning the irradiation cases, we should not be too hasty in drawing conclusions. That is the reason I do not wish to state my findings, because they should not be reported until five years have elapsed.

The next thing I would like to comment on is your question concerning cystic mastitis. I am one of those who does not agree that every woman who has cystic mastitis should have her breast removed. I believe many women develop cystic mastitis and that there is such a great amount of the disease that it would be an untenable position for a surgeon to take to operate on every case. I wrote to Dr. Geschickter to ask what percentage of cases developed cancer that had cystic mastitis in Bloodgood's cases which we followed five years. He informed me that only one in 600 cases developed cancer of the breast. So there you are. I would almost rather see a blue-dome cyst in an average woman 45 years of age than not, because she has a better chance of going through life without developing a mammary cancer than the average woman.

MILTON FRIEDMAN, M.D. (New York City): With reference to the treatment of carcinoma of the breast pre-operatively, we have adopted a working technic based upon our experience with the study of rates of response of upper respiratory tract tumors.

Our average technic entails the use of four portals: anterior and posterior axillary, and medial and lateral breast. The daily dose consists of 150 r to each of two

portals. Because each region is irradiated every other day instead of every day, the low cumulative increment permits the recovery factor to gain ascendency more readily than if a higher daily tumor dose were given.

With such a daily dose, the healing phase is reached from the twenty-eighth to the thirty-fifth day, and the reactions start to heal while the radiation is being given. Any therapy given thereafter consequently becomes much less effective.

Our experience with squamous-cell carcinoma indicates that the behavior of the tumor parallels the skin reactions to a certain extent. A Grade III carcinoma which has not been completely destroyed by fractionated irradiation, becomes, by the twenty-eighth day, a Grade II or I, by virtue of the persistence of the more mature cells and a maturation of the residual, less-differentiated cells. These cells, from the twenty-eighth to the thirty-fifth day, mature not only histologically but also physiologically, and thus become more radioresistant. Therefore, the greatest radiation effect is obtained within the first three weeks.

The size of the tumor is observed as accurately as possible before and during treatment. On or about the twenty-first day, we take stock of the situation. If there is some significant shrinkage ranging from 25 to 35 per cent, experience seems to indicate that there will be further beneficial effect in the next week by continuing the irradiation.

If we find that the carcinoma has not been very much affected, the treatment is terminated by the twenty-first day in order that the subsequent operation be not postponed and rendered more difficult because of the severe skin reactions.

VISCEROPTOSIS DURING ARTIFICIAL PNEUMO-PERITONEUM TREATMENT

By ANDREW L. BANYAI, M.D., *Wauwatosa, Wisconsin*

From Muirdale Sanatorium, Wauwatosa, Wisconsin, and the Department of Medicine, Marquette University School of Medicine, Milwaukee

SINCE 1929, when I began to use artificial pneumoperitoneum systematically, I have had the opportunity to observe the effect of repeated injections of air and oxygen upon the position of the abdominal viscera. It was stated in a previous publication (1) that artificial pneumoperitoneum causes not only an elevation of the diaphragm but also a downward displacement of the liver and the spleen. The downward displacement of these organs can be explained, first, by the pressure of the injected gas, and, second, by the diminution of the negativity of the subdiaphragmatic pressure which normally exerts an upward pull upon the subdiaphragmatic organs.

The purpose of this paper is to present a series of measurements made on roentgenograms of patients who were receiving artificial pneumoperitoneum for the treatment of pulmonary tuberculosis. A group of 54 unselected cases was studied. Of these, 12 had moderately advanced and 42 far-advanced tuberculosis, according to the classification of the National Tuberculosis Association. The films were taken at the end of maximum inspiration and expiration, in the upright position, from a distance of six feet. Thus, including the films taken before treatment, 312 roentgenograms were measured. Films taken during treatment are as shown in Table I.

On the pre-treatment films the distance from the level of the upper border of the first dorsal vertebra to the highest point of the right dome of the diaphragm was measured. During the treatment, the distance was measured from the level of the upper border of the first dorsal vertebra to the convexity of the liver, corresponding to the highest point of the diaphragm.

The amount of air injected at each treatment varied from 500 to 1,000 c.c. The treatments were given at weekly intervals

TABLE I.—FILMS TAKEN DURING TREATMENT

No. Films	No. of Treatment
33	1
6	3
4	4
2	5
8	6
1	7
1	8
3	9
8	10
1	11
3	12
1	13
2	14
8	15
4	16
2	17
4	19
2	20
4	21
4	22
1	25

at the beginning and two weeks apart when the pneumoperitoneum was well established. There were only two instances out of 33 measurements in which hepatoptosis was absent after the first treatment in both respiratory phases. Following the first treatment, the hepatoptosis varied from 0.5 to 5.3 cm. on inspiration, and from 0.4 to 5.9 cm. on expiration. The extent of ptosis was greater on expiration than on inspiration in 20 cases (60.6 per cent), following the first treatment; in four instances (66.6 per cent) after the third treatment; in four instances (50.0 per cent) after the sixth treatment; in five cases (62.5 per cent) after the tenth treatment, and in five cases (62.5 per cent) after the fifteenth treatment. This relationship was not studied in groups of less than five observations.

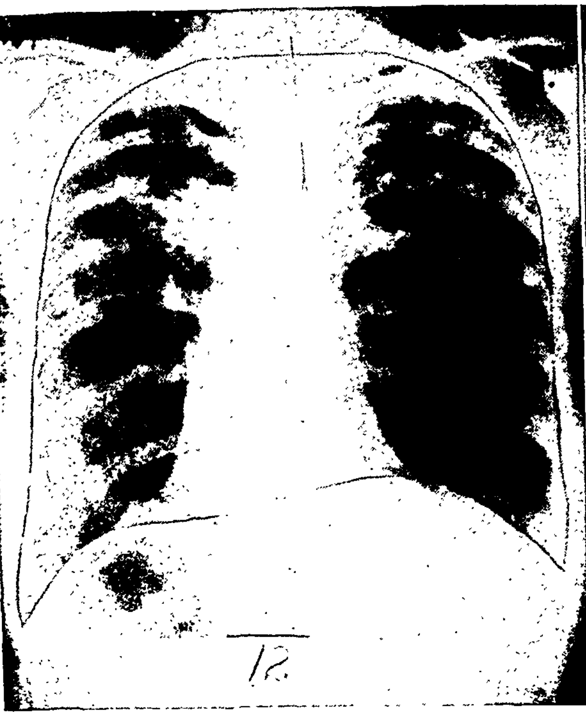


Fig. 1.

Fig. 2.

Fig. 1. Before treatment; maximum inspiration. The twelfth dorsal vertebra is marked.
Fig. 2. Before treatment; maximum expiration. The twelfth dorsal vertebra is marked.

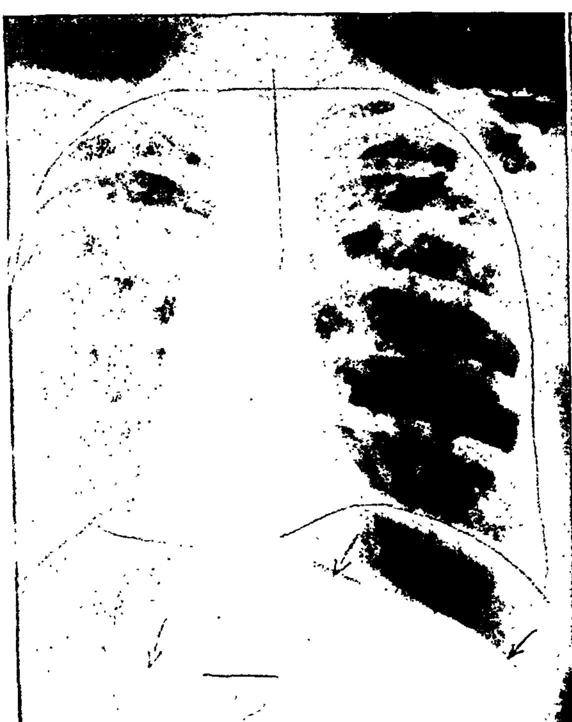


Fig. 3.

Fig. 4.

Fig. 3. After the intraperitoneal injection of 600 c.c. of air; first treatment; maximum inspiration. The twelfth dorsal vertebra is marked.

Fig. 4. After the intraperitoneal injection of 600 c.c. of air; first treatment; maximum expiration. The twelfth dorsal vertebra is marked.

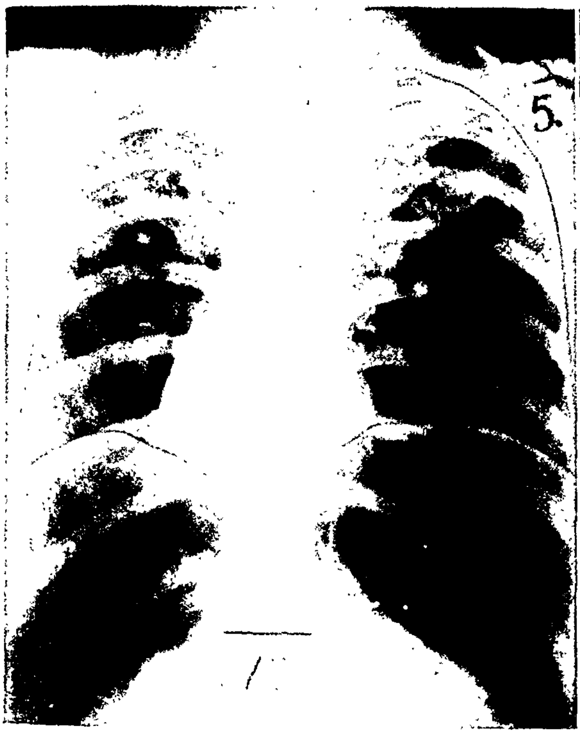


Fig. 5.

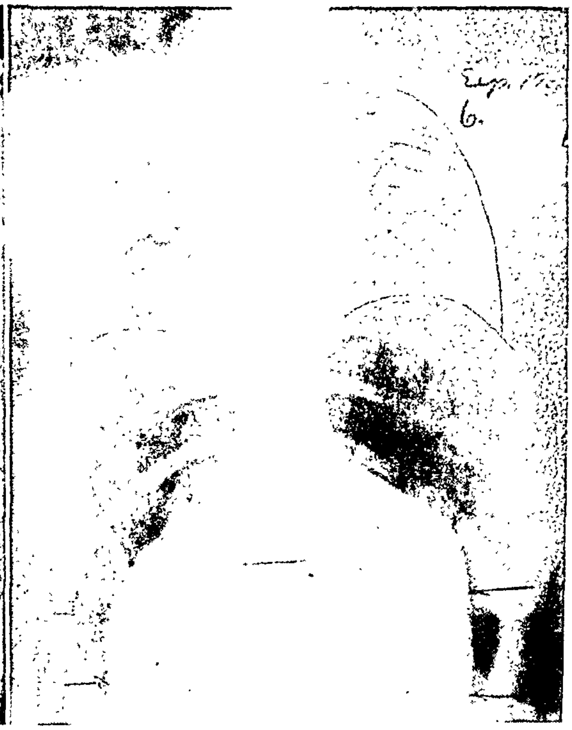


Fig. 6.

Fig. 5. After the nineteenth pneumoperitoneum treatment; no phrenic nerve block; maximum inspiration. The twelfth dorsal vertebra is marked.

Fig. 6. After the nineteenth pneumoperitoneum treatment; no phrenic nerve block; maximum expiration. The twelfth dorsal vertebra is marked.

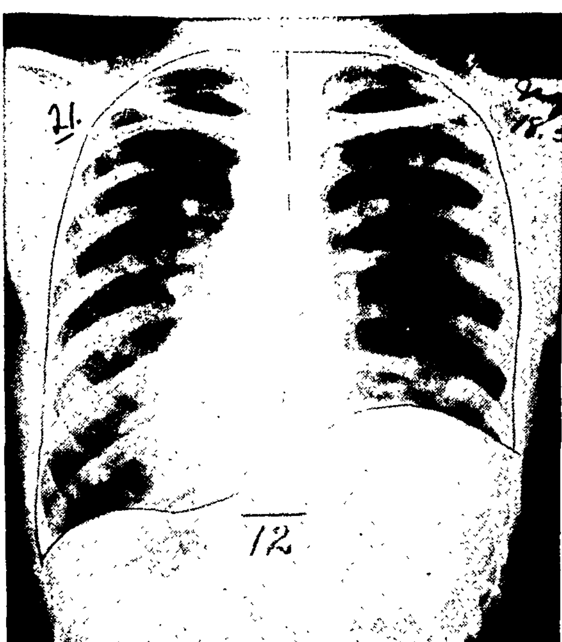


Fig. 7.

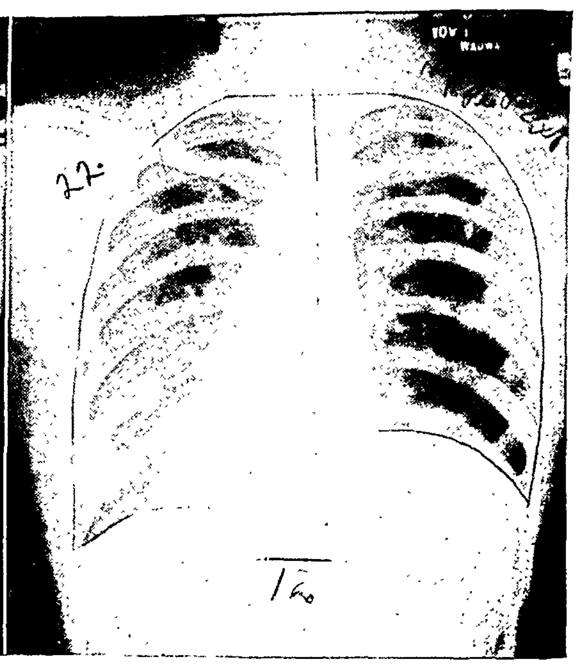


Fig. 8.

Fig. 7. Right phrenic nerve block. Note the high position of the right dome of the diaphragm; maximum inspiration; before pneumoperitoneum treatment. The twelfth dorsal vertebra is marked.

Fig. 8. Right phrenic nerve block. Note the high position of the right diaphragm; maximum expiration; before pneumoperitoneum treatment. The twelfth dorsal vertebra is marked.

The difference between the extent of the ptosis during inspiration and expiration is influenced by the corresponding variations in the subdiaphragmatic pressure. Subatmospheric (negative) pressure was observed in the subdiaphragmatic region by Keppich (2), Melchior (3), Krause (4), and Overholt (5). Riviere (6) states that the subdiaphragmatic pressure varies inversely with the intrapleural pressure. Overholt (5) found in animal experiments that the subdiaphragmatic and intrapleural pressures fluctuate in the same direction during respiration, and not inversely. The explanation of the varying level of the convexity of the liver, in the presence of pneumoperitoneum, might be found in the possibility that the subdiaphragmatic pressure may vary either correspondingly or inversely with the intrapleural pressure in different individuals. If, however, it is accepted that the increase in the circumference of the lower thorax during inspiration is prone to increase the negativity of the pressure in the upper peritoneal cavity, the assumption is reasonable that the suction effect of this increased negativity draws a certain amount of the injected air to underneath the diaphragm. The air thus collecting in the subdiaphragmatic region tends to neutralize the negative pressure and its pulling effect upon the liver. If this neutralizing effect is greater during inspiration than expiration, the hepatoptosis is greater also. If, on the other hand, the amount of air drawn to the subdiaphragmatic area is not sufficient to neutralize the negative pressure, the latter exerts an upward-pulling effect upon the liver, and the degree of ptosis is less during inspiration than during expiration. The main factors that may influence these changes are the functional integrity of the respiratory muscles, including the diaphragm; the presence or absence of arti-

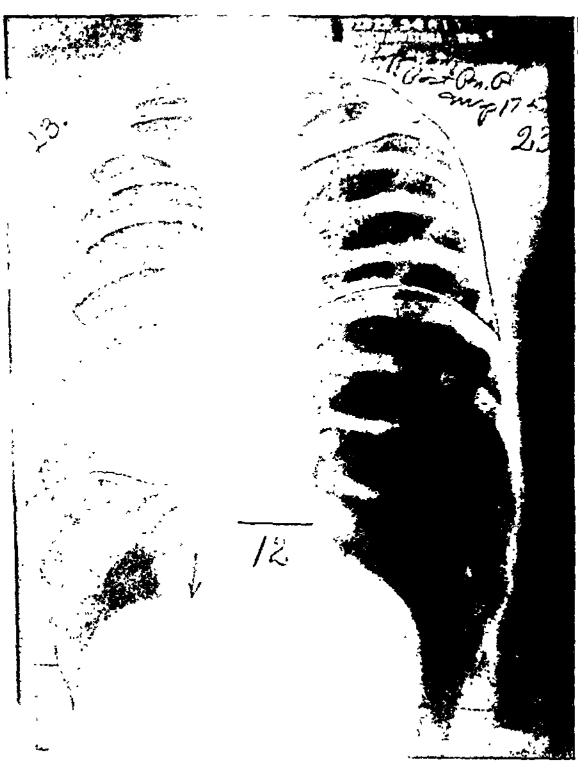


Fig. 9.

Fig. 10.

Fig. 9. Right phrenic nerve block and pneumoperitoneum, after the nineteenth treatment; maximum inspiration. The twelfth dorsal vertebra is marked.

Fig. 10. Right phrenic nerve block and pneumoperitoneum, after the nineteenth treatment; maximum expiration. The twelfth dorsal vertebra is marked.

ficial pneumothorax, or surgical paralysis of the phrenic nerve; the functional capacity of the lungs (parenchymal tuberculosis, atelectasis, fibrosis, emphysema), and the presence of adhesions in the pleural cavity or in the corresponding abdominal sector.

These factors, together with the status and tonicity of the abdominal wall, the type of respiration (thoracic or abdominal), the sthenic or asthenic habitus of the individual, and the function of the abdomino-diaphragmatic reflex, are the determinants of the degree of ptosis in general, and are responsible for the fact that oftentimes the same amount of injected air induces different degrees of ptosis in different individuals.

Roentgenologic measurements of the apicobasal relaxation of the lung during pneumoperitoneum treatment were reported in a previous communication (7). It was found that repeated injections of air into the peritoneal cavity were capable of elevating the level of the right dome of the diaphragm by as much as 7.3 cm. on inspiration and 6.4 cm. on expiration. Clinical observations show that a corresponding relaxation of the lung creates mechanical and physiologic conditions in the lung that are favorable to the healing of pulmonary tuberculosis (8). A study of the simultaneous hepatoptosis, in relation to the rise of the diaphragm, revealed the following data. After the first treatment, on inspiration the ptosis was greater than the rise of the right dome of the diaphragm in 69.6 per cent, it was smaller in 21.3 per cent, and the two were equal in 9 per cent. After the third treatment, on inspiration the ptosis was greater than the diaphragmatic rise in 66.7 per cent, it was smaller in 16.6 per cent, and the two were equal in 16.6 per cent. After

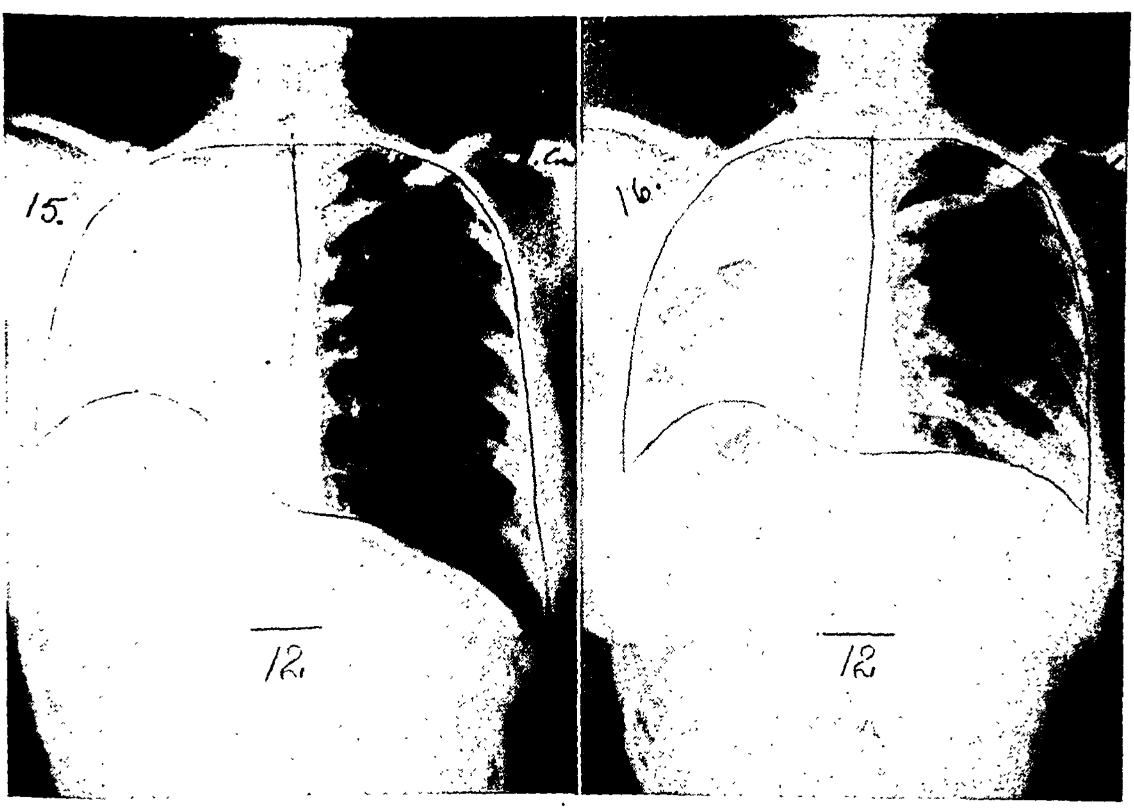
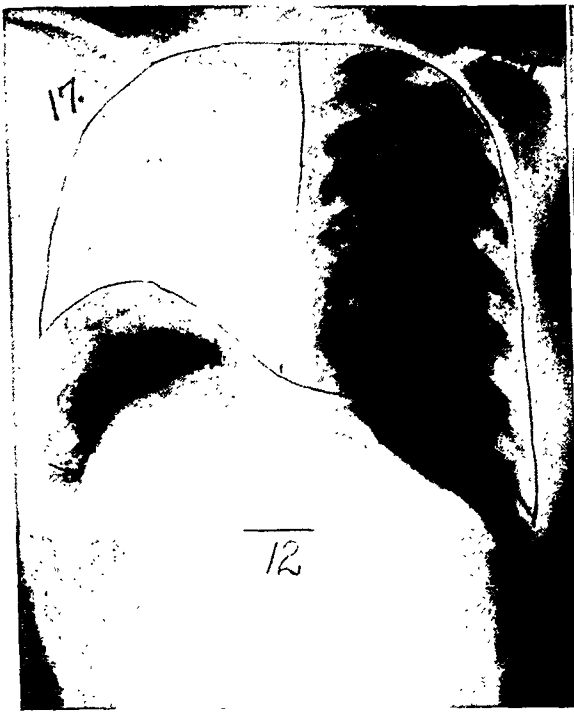


Fig. 11. Fig. 12.

Fig. 11. Left phrenic nerve block. Note the high position of the left dome of the diaphragm; maximum inspiration; before pneumoperitoneum treatment. The twelfth dorsal vertebra is marked.

Fig. 12. Left phrenic nerve block. Note the high position of the left dome of the diaphragm; maximum expiration; before pneumoperitoneum treatment. The twelfth dorsal vertebra is marked.



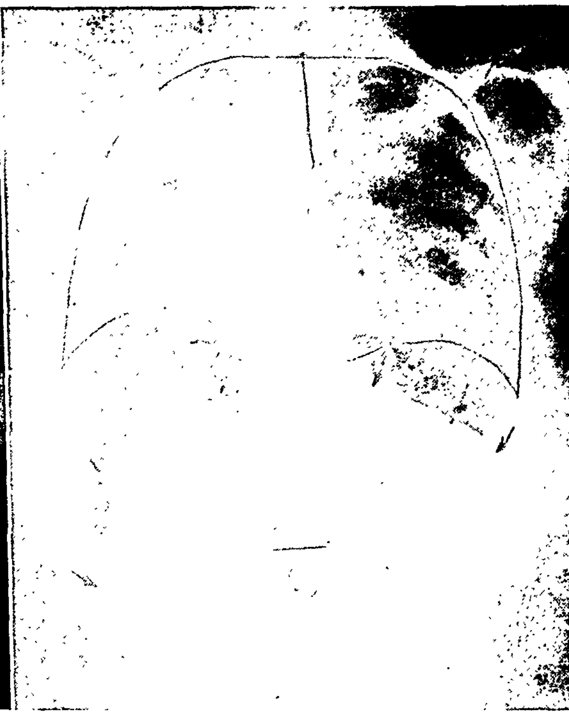
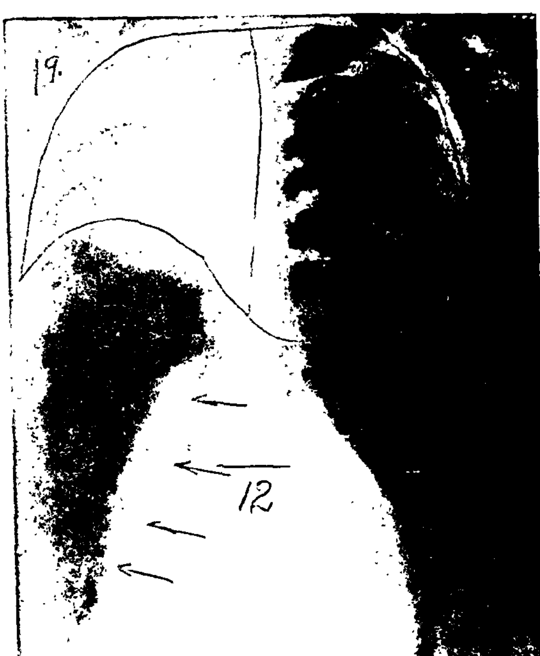


Fig. 13.

Fig. 14.

Fig. 13. Left phrenic nerve block and pneumoperitoneum, after the intraperitoneal injection of 750 c.c. of air; first treatment; maximum inspiration. The twelfth dorsal vertebra is marked.

Fig. 14. Left phrenic nerve block and pneumoperitoneum, after the intraperitoneal injection of 750 c.c. of air; first treatment; maximum expiration. The twelfth dorsal vertebra is marked.



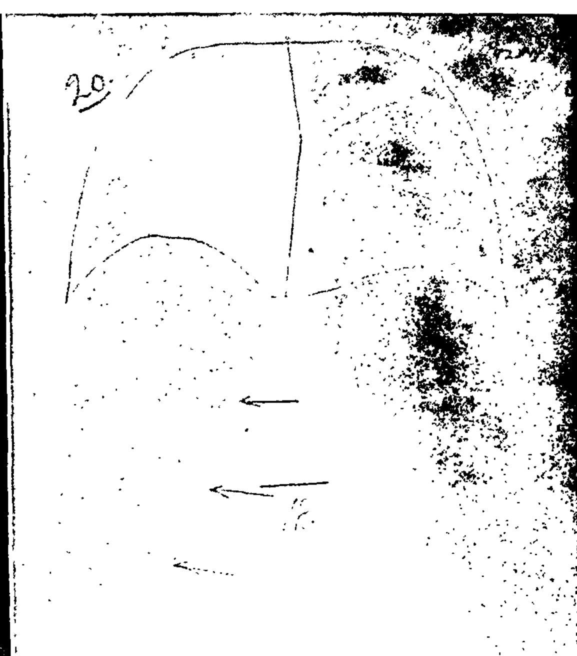


Fig. 15.

Fig. 16.

Fig. 15. Left phrenic nerve block and pneumoperitoneum, after the fifteenth treatment; maximum inspiration. The twelfth dorsal vertebra is marked.

Fig. 16. Left phrenic nerve block and pneumoperitoneum after the fifteenth treatment; maximum expiration. The twelfth dorsal vertebra is marked.

TABLE II.—DEGREE OF HEPATOPTOSIS IN CENTIMETERS

No. Treatments		1	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	19	20	21	22	25
No. Cases		33	6	4	2	8	1	1	3	8	1	3	1	2	8	4	2	4	2	4	4	1
Inspiration	Average	1.5	2.3	2.7	3.8	4.6			3	3.8		3.3			3.4	3.4	3.2	4.7	3.3	5.6	3.5	
	Maximum	4.6 5.3[1]	3.6 2[1]	4	3.4 4.2[1]	5 1.4[1]	2.7	5.3[1]	3.5 3.2[1]	5.9 3.2[1]	4	4.1	4.4	3.5	4.5 8.9[1]	4.2	3.3	6.5 6.5[1]	5.2	6.8	4 3[1]	5.5
Expiration	Average	1.7	2.5	2.7	4.1	4.8			2.5	4.4		3.9			4.7	4	3.3	3.5	3.6	5.2	3.8	
	Maximum	5.9 3.1[1]	4.2 3.6[1]	4.2	2.8 5.6[1]	6.3 1.9[1]	4.2	5.8[1]	3.9 2.2[1]	6.1 4.4[1]	4.6	5.6	4.4	2.5	5.2 6.4[1]	5.5	3.4	5.2 5.4[1]	4	6.7	4 4.2[1]	3.7

[1] Surgical paralysis of the phrenic nerve and pneumoperitoneum.

the sixth treatment, on inspiration the ptosis was greater than the diaphragmatic rise in 50 per cent and smaller in 50 per cent. After the tenth treatment, on inspiration the ptosis was greater than the diaphragmatic rise in 50 per cent, smaller in 25 per cent, and the two were equal in 25 per cent. After the fifteenth treatment, on inspiration the ptosis was greater than the diaphragmatic rise in 62.5 per cent, and smaller in 37.5 per cent. On expiration the following findings were recorded: after the first treatment, the ptosis was larger than the diaphragmatic rise in 57.6 per cent, smaller in 36.3 per cent, and the two were equal in 6 per cent. After the third treatment, the ptosis was larger than the diaphragmatic rise in 37.5 per cent, and smaller in 62.5 per cent. After the tenth treatment, the ptosis was larger than the diaphragmatic rise in 62.5 per cent, smaller in 25 per cent, and the two were equal in 12.5 per cent. After the fifteenth treatment, the ptosis was larger than the diaphragmatic rise in 50 per cent and smaller in 50 per cent.

Calculations were made also for the purpose of determining how much of the width of the air pocket in the subdiaphragmatic region represents hepatoptosis, and rise of the diaphragm. The following data were found concerning the division of the width of the *average* air pocket on inspiration. After the first treatment, 55.6 per cent was taken up by ptosis and 44.4 per cent by the elevation of the diaphragm; after the third treatment, 63.9 per cent by ptosis and 36.1 per cent by diaphragmatic elevation; after the sixth treatment, 64.8 per cent by ptosis and 35.2 per cent diaphragmatic elevation; after the tenth treatment, 57.6 per cent by ptosis and 42.4 per cent by diaphragmatic elevation; the corresponding figures for the fifteenth treatment were 52.3 and 47.7, respectively. The division of the width of the *average* air pocket on expiration was as follows: after the first treatment, 56.6 per cent was taken up by ptosis and 43.3 per cent by the elevation of the diaphragm. The corresponding

figures during subsequent observations were: after the third treatment, 64.1 and 35.8; after the sixth treatment, 62.3 and 37.6; after the tenth treatment, 59.4 and 40.5, and after the fifteenth treatment, 54.6 and 45.3 per cent, respectively.

No accurate measurements are available as to the degree of lienoptosis during the course of artificial pneumoperitoneum treatment. This is due to the fact that it was impossible to determine the exact position of the spleen in the two respiratory phases before air was injected into the peritoneal cavity. A comparison of the highest point of the spleen with that of the liver, during treatment, suggests that there exists a relationship between the rise of the left dome of the diaphragm and the lienoptosis similar to that between the rise of the right dome of the diaphragm and hepatoptosis.

SUMMARY

Measurements and roentgenograms are presented to illustrate the varying degrees of visceroptosis that occur during the course of artificial pneumoperitoneum treatment of pulmonary tuberculosis.

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PRACTICAL CONSIDERATIONS IN THE COMPARISON OF DEPTH DOSES ACHIEVED BY 1,000 AND 200 KILOVOLT X-RAY APPARATUS[1,2]

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THE question of how great a gain in depth dose is obtained by the use of kilovoltages above 200 is often answered merely by stating the values for a depth of 10 cm. (D_{10}), obtained for various fields by using a thimble chamber in a large phantom, and comparing them to those obtained under similar conditions with a 200 kv. apparatus. For example, in the case of a field 10 × 10 cm. the D_{10} for radiation from our 1,000 kv. tube is more than 30 per cent greater than that from our 200 kv. tube, when a field of the same size is used with the same target to skin distance. This statement is impressive, for it indicates that if the same skin dose is maintained, more than 30 per cent greater dose can be delivered to a deep tumor. Further, if certain practical factors were left out of consideration, a gain of more than 60 per cent in the dose to the tumor might be anticipated by the use of two fields and, by using multiple fields, an enormous gain might be expected. In actual clinical practice, however, the relative advantages of radiations of two different qualities are not readily pictured by stating a few comparative numbers, but are dependent, in a variety of ways, on the clinical problems involved. The general necessity for using cross-fire technic in treating most deep neoplasms with externally applied x-rays or gamma rays, makes necessary the comparison of surface as well as depth doses under different conditions.

With these points in mind, we compared the results of cross-firing beams through thicknesses of from 12 to 24 cm., using data obtained both in "unlimited" phantoms and in those limited to the specified values. By an "unlimited" phantom is meant one in which there is at least 15 cm. of material below each level to provide almost the maximum possible amount of back-scattered radiation. It is inconvenient to use water for limited sections because of the difficulties involved. Wax has certain unfavorable properties (1). At the Memorial Hospital, in New York City, a cellulose material, known commercially as Masonite Presdwood (untempered), was found to be a medium very comparable to tissue for use as a phantom. This is obtainable in sheets from about 3 to 12 mm. thick which can be very conveniently stacked to make phantoms of the desired thickness. We used this material in the present study.

The ionization measurements were made with a standard Victoreen condenser r-meter using a 25 r thimble chamber. The constancy of output of the apparatus was under continual measurement, making the mutual consistency of the data accurate (less than 1 per cent of error). All surface values refer to readings with the chamber one-half immersed in the surface. Admittedly, the transition effects at the surface and the dosages measured by a chamber of the size and shape used may not be an exact measure of the effects produced in tissue, but there are reasons to believe that the results thus obtained approximate them sufficiently to serve in the comparisons undertaken in this paper. The data are not presented as being precisely those which would be obtained for radiations of the specified quality under ideal conditions, for certain conditions are peculiar to our ap-

[1] Presented before the Fifth International Congress of Radiology, at Chicago, Sept. 13–17, 1937.
[2] These investigations were made possible through the support of the Christine Breon Fund for Medical Research. Many improvements in the operation of the 1,000-kilovolt apparatus have been made possible through the financial support of the Anna Fuller Fund.

paratus (2) and technic of research, but the data are characteristic of radiations in the regions considered.

For purposes of simplicity in phraseology, we use the expressions "1,000 kv.

for all qualities of radiations. The two lower curves show the decrease in intensity of the primary beam when phantom material replaces air, and scattered radiation is eliminated by using extremely small

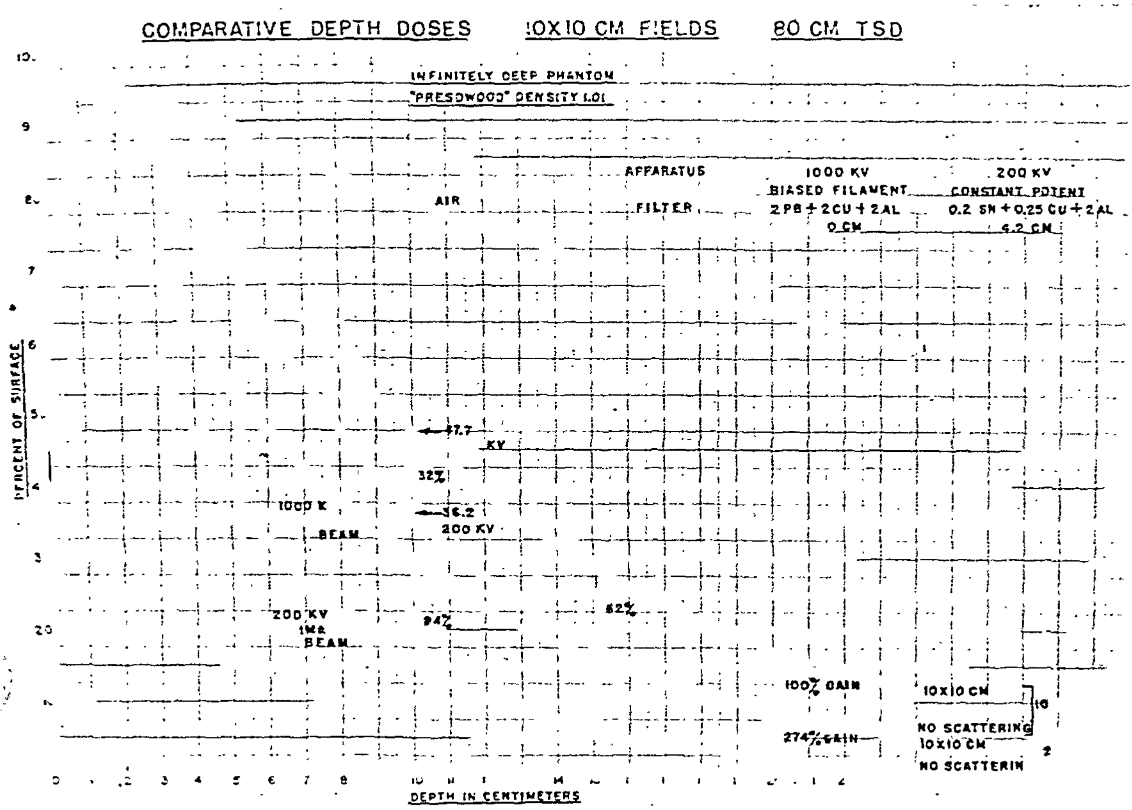

Fig. 1. A comparison of the depth dose curves from 200 and 1,000 kv. apparatus for 10 × 10 cm the primary beams.

radiation" or "beam," and "200 kv. radiation" or "beam," when we mean the x-rays produced by our 1,000 kv. high frequency x-ray apparatus and those by our 200 kv. constant potential apparatus, respectively. The quality of the beams was such that the measured half value layers in presdwood were 7.0 cm. for the 1,000 kv. and 4.2 cm. for the 200 kv. apparatus.

As the potential applied to an x-ray tube is increased, the beam produced becomes more penetrating. That this is true can be seen in Figure 1. The uppermost curve in this figure shows the decrease in intensity in air in accordance with the inverse square law, assuming the intensity at a distance of 80 cm. to be 100. This curve is the same

beams. The percentage of tween these curves becom greater depths. The gains beam of the 1,000 kv. ra depths of 5, 10, and 20 cm 274 per cent, respectively.

When larger beams ar tered radiation which th traverse the phantom fraction to the total int in Figure 1 labelled 1 depth doses along th when the beam is 10 face. The greater wider angle of sc radiation arising fro sult in a larger con

dose than is the case with the 1,000 kv. radiation. This makes the difference in the depth doses much less than that for the

It is evident that the smaller the field used, the greater is the relative advantage realized with 1,000 kv. radiation, the maxi-

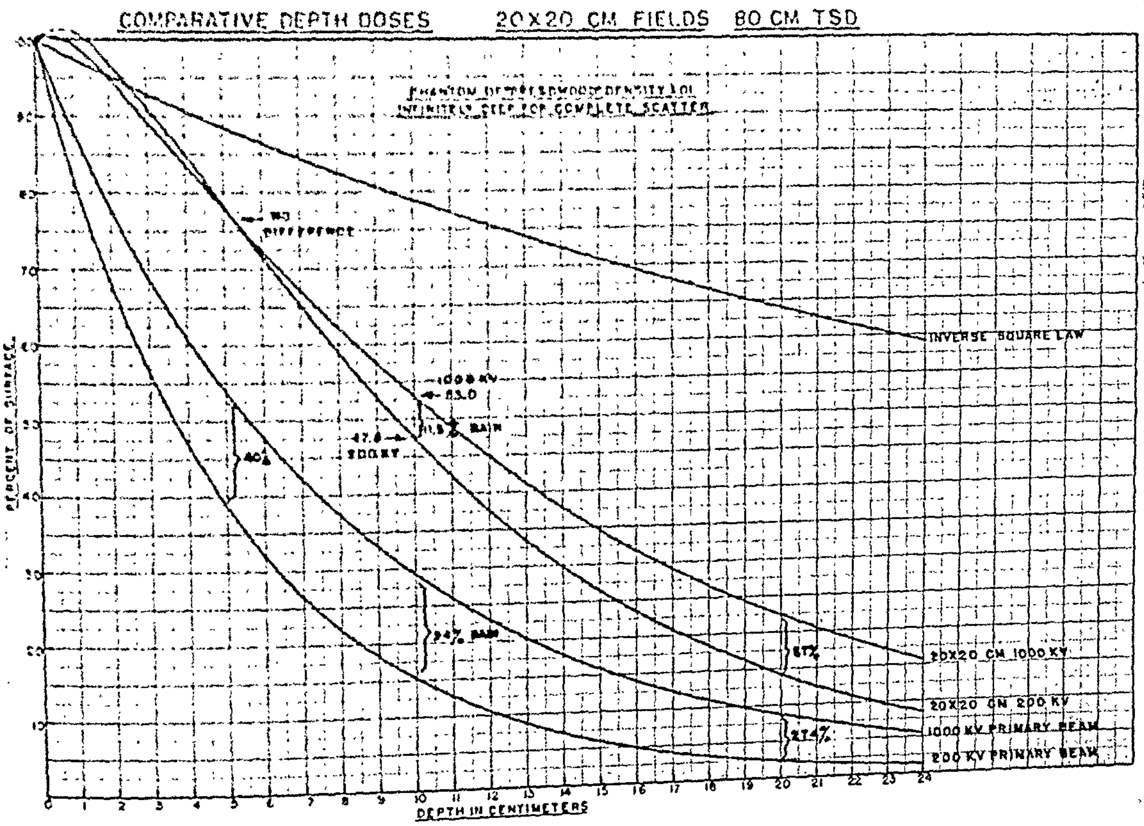

Fig. 2. A comparison of the depth dose curves from 200 and 1,000 kv. apparatus for 20 × 20 cm. fields and the primary beams.

primary beams alone, a gain of only 32 per cent at a depth of 10 cm. with the higher voltage, instead of 94 per cent as for the primary beam.

If a still greater volume of material is irradiated by increasing the size of the beam to 20 × 20 cm. at the surface (Fig. 2), a further increase in the relative contribution by scattered radiation in the 200 kv. beam results in making even smaller the percentage of difference between the two depth dose curves. Through the use of 1,000 kv. radiations, the gain in the depth dose at a depth of 10 cm. is then 11.5 per cent. This is much less than the gain of 32 per cent obtained when the fields 10 × 10 cm. in size are used, and the gain of 94 per cent when a very small field is used (thus having only the primary radiations).

mum gain possible being represented by the smallest possible field.

A further difference in the depth dose curves of the two radiations is their difference in shape, evident in Figure 1. The contribution to the depth dose by scattered radiation builds up more rapidly as the beam enters the phantom in the case of the 200 kv. radiation, so that, for the first few centimeters, the values may be larger than those for the 1,000 kv. radiation. For the 20 × 20 fields, the build-up of scattered radiation for the 200 kv. beam is great enough to result in a superiority in the depth doses of this beam for the first five centimeters. When a depth of 20 cm. is reached, however, the gain with 1,000 kv. radiation is 57 per cent.

In Figure 3 are shown the depth dose

curves for the two qualities of radiation using fields 10 × 10, 15 × 15, and 20 × 20 cm. in size. It can be seen that the increase

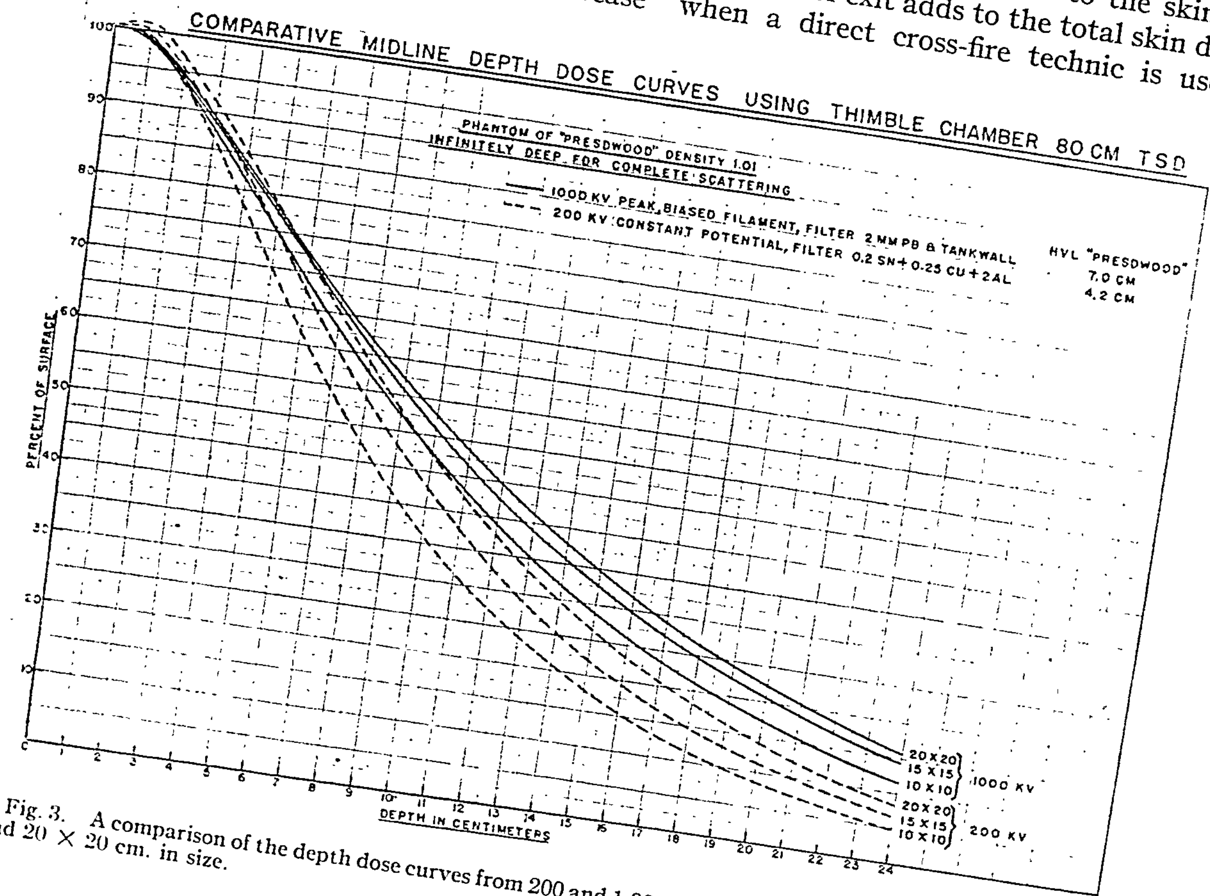

Fig. 3. A comparison of the depth dose curves from 200 and 1,000 kv. apparatus for fields 10 × 10, 15 × 15, and 20 × 20 cm. in size.

in depth dose of the 1,000 kv. beam is not so great with large fields as with small. This demonstrates that 1,000 kv. radiations are less dependent on scattering in building up the depth dose, thus becoming more advantageous as the size of the field becomes smaller. Below the depth of 10 cm., all the curves are higher for 1,000 kv. than those for 200 kv. radiations, which again illustrates the increasing superiority of the higher voltage with increasing depths.

These deep levels, for which the 1,000 kv. radiation gives so much larger depth doses, correspond, in the irradiation of a patient, to levels as deep as those of the skin opposite the fields of treatment. Moreover, the gain in depth dose at the level of the exit field is relatively larger than that for depths midway between the skin surfaces. This increased dose to the skin at the point of exit adds to the total skin dose when a direct cross-fire technic is used.

For the sufficient dosage of deep neoplasms by the external application of x-rays or gamma rays, it is necessary to cross-fire beams through the malignant region, and, in most cases, there is an overlapping of the fields of entrance and exit. Consequently, a comparison of the depth doses realized by different radiations in different conditions of treatment should take into consideration the effects of direct cross-fire.

The depth dose measured in an unlimited phantom at a level corresponding to that of the field of exit includes the utilization of back-scattered radiation from the material below that level. In actual sections of the body, the surface of the skin at the point of exit of the x-ray beam receives from little to no back-scattered radiation.

Since the difference between the dose at a depth in the body and that given the skin is important to the clinician, the data taken

If the phantom is limited to a thickness of 12 cm., leaving only air beyond it, there is less material to produce back-scattering

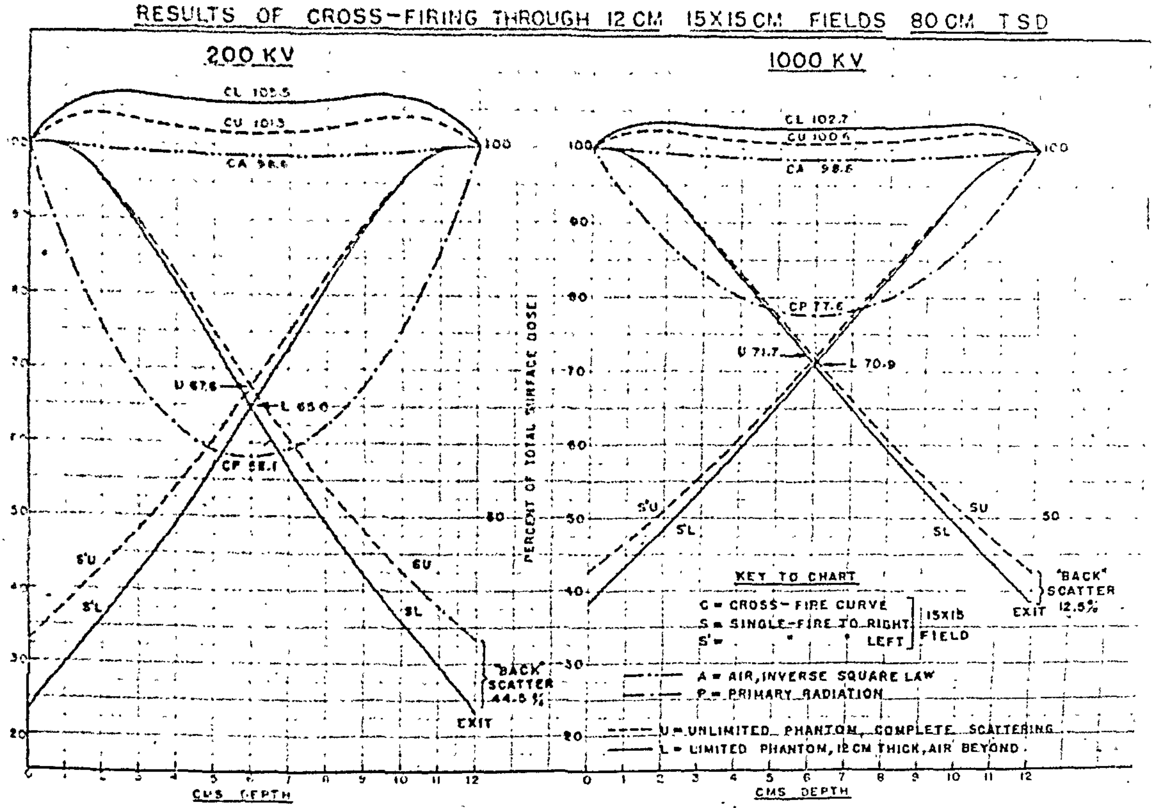

Fig. 4. A comparison of the curves resulting from the cross-firing of beams through a 12 cm. thickness of phantom for fields 15 × 15 cm. in size.

in a limited phantom should be considered when direct cross-fire is used. In this instance, the dose at the skin surface where the beam leaves the body must be added to the dose given when this field becomes a surface of entrance for the beam. This is illustrated in Figure 4 which represents a case of cross-firing through a section 12 cm. thick, using fields 15 × 15 cm. in size. The dotted curves *SU* and *S'U* are the depth dose values measured in an unlimited phantom, the beams traversing to the right and left, respectively. The curve *CU* is the sum of the doses given by the beam from the left and the beam from the right with the values multiplied by the proper factor to make the surface dose 100, thus simulating a depth dose curve obtained by direct cross-fire.

below each level and the intensity at each level is reduced, the reduction being greater the less material there is below each level. The intensity at the surface of entrance is changed only slightly because the 12 cm. of material below provides nearly complete back-scattering. The depth dose values relative to this new surface value are shown in the solid line curves *SL* and *S'L* and are the modifications of *SU* and *S'U* brought about by limiting the phantom. The largest difference in the two sets of curves is at the exit surface where the removal of back-scattering material decreased the exit dose more for the 200 kv. than for the 1,000 kv. radiations. The term "back-scatter," in its usual connotation, refers to the difference of the readings with and without material below, divided

by the reading with air below. In this sense, the percentage of "back-scatter" for the 200 kv. radiation is 44.5 compared to 12.5 for the 1,000 kv. radiation. In terms of the total radiation at this depth, the back-scattered radiation comprises 30.8 and 11.1 per cent, respectively, so that, by the removal of back-scattering material, the exit doses are reduced to 69.2 and 89.9 per cent, respectively, of their values in the unlimited phantom. At the center of the phantom where there is about 85 per cent of the complete amount of back-scattered radiation for each case, the center dose for the limited phantom is reduced to 65.0 divided by 67.6, or 96.2 per cent of the unlimited phantom value in the case of 200 kv. radiation, and 71.7 divided by 70.9, or 98.8 per cent in the case of 1,000 kv. radiation. The limitation of the phantom reduced the total surface dose relatively more than it reduced the total internal doses, so that the cross-fire depth doses for the limited phantom, shown in the solid line curves *CL*, were increased. For 200 kv. radiation, the limited phantom received a center dose 4 per cent greater than that for the unlimited one, while for 1,000 kv. this increase was only 2 per cent.

COMPARISON OF RESULTS OF CROSS-FIRING
15X15 CM FIELDS 80 CM TSD

PRESDWOOD PHANTOM THICKNESS	RADIATION QUALITY	U. UNLIMITED PHANTOM	L. LIMITED PHANTOM	PERCENT GAIN BY LIMITED	GAIN OVER 200 KV (1) CASE L.	GAIN OVER 200 KV (2) CASE L.
12 CM	1. 200 KV 0.5 CU	100.3	104.2	3.9		-1.2
	2. 200 KV COMPOSITE SN	101.5	105.5	4.0	+1.2	
	3. 1000 KV PB FILTER	100.6	102.7	2.2	-1.5	-2.7
16 CM	200 KV (1)	88.6	91.4	3.2		-2.4
	200 KV (2)	90.5	93.6	3.3	+2.4	
	1000 KV (3)	93.6	95.2	1.7	4.2	1.7
20 CM	200 KV (1)	74.4	76.4	2.7		-3.3
	200 KV (2)	76.8	78.9	2.7	3.3	
	1000 KV (3)	84.6	85.5	1.1	12	8.5
24 CM	200 KV (1)	59.5	60.6	2.1		-4.8
	200 KV (2)	62.25	63.5	2.1	4.8	
	1000 KV (3)	74.6	75.6	1.1	25	19

Fig. 5. A chart showing the mid-line center depth doses resulting from the cross-firing of beams of three different qualities through limited and unlimited phantoms of different thicknesses.

Three things, then, are evident. First, in using 1,000 kv. radiation the difference between the cross-fire values obtained from limited and unlimited phantoms is not so great as for the 200 kv. radiation, though the differences are small. Second, although the center doses resulting from single-fire are higher for the 1,000 kv. radiation, the exit dose is proportionately higher; consequently, the center doses resulting from cross-fire through this thin section are actually lower for the 1,000 kv. radiation. Thus the maximum dose by cross-fire oc-

curs below the surface and is greater for 200 kv. radiation (Fig. 4). For 200 kv. radiations, a maximum dose of 107 per cent, relative to the surface, is reached at a depth of 2.5 cm., while for the 1,000 kv. radiations, a maximum of 103.5 per cent is reached 2 cm. below the surface. Thus, using direct cross-fire through thin sections, the greatest reaction may be caused a short distance under the skin. If the neoplasm is only a few centimeters below the skin, in a tonsil for example, greater advantage is gained by using 200 kv. radiation.

For smaller fields and thicker sections, the doses at a depth of the first few centimeters may not rise much above the surface value, but, in any instance, they will be relatively greater for 200 kv. than for 1,000 kv. radiations. Consequently, for cases in which the tolerance dose may be considered to be determined by radiosensitive regions in the sub-surface levels, the depth doses calculated relative to these sub-surface regions show a greater gain by 1,000 kv. over 200 kv. radiation than those which are given relative to the skin surface, as in the charts (Figs. 5 and 6). For example, in Figure 4, the center dose relative to the position of the maximum dose is 105.5 divided by 107, or 98.6 per cent for 200 kv., and 102.7 divided by 103.5, or 99.2 per cent for 1,000 kv. radiation. This amounts to saying that the cross-fired 1,000 kv. beams produce a more homogeneous distribution of dosage, evidenced in the figure by the flatter 1,000 kv. curve. The ionization is more homogeneous throughout the irradiated volume when 1,000 kv. radiation is used, because of two other factors, first the lateral variation parallel to the surface over the area of the beam at the depths is less, and second, the presence of bones and air spaces does not change the distribution so much.

Thus, if the tolerance dose is considered to be that at the surface, it would appear that in some cases—for example, those which appear as negative gains in the charts—the 1,000 kv. radiation is slightly disadvantageous. If it is desired, however, to have the more homogeneous distribution of dosage so that the dose to be tolerated in any region is not too much greater than that to be tolerated in another, the 1,000 kv. radiation is better. It can be concluded that it is not disadvantageous to use 1,000 kv. radiation in any case, but that the advantages demonstrable from thimble-chamber measurements for some of the cases considered are so small that they may not be of practical importance.

It is interesting to note the cross-fire curves, *CP* for the primary beams, and *CA* for the beams in air. The building-up of scattered radiation as the 200 kv. beam enters the phantom produces a center dose by single-fire even larger than that for cross-fire of the primary beam, while in the case of the 1,000 kv. radiations the scattered radiation is not a large enough factor to produce this effect. With variation of intensity according to the inverse square law, the dose at the center is 98.6 per cent, which is not much less than the 100 per cent for parallel beams or infinite target–skin distance. This shows that the use of longer target–skin distances for irradiating thin sections would not produce appreciable increases in the depth doses.

The values in Figure 5 were obtained by using the same procedure as explained for Figure 4 on thicker sections. The results of using a working filter of 0.5 mm. of copper on the 200 kv. apparatus are also included because this lesser filtration is often used in clinical treatments. A comparison of the first two columns shows that the limited phantom gave larger relative center doses than the unlimited phantom. In the third column we see that this increase became smaller at the greater thicknesses, and that for each thickness the increase was less for the 1,000 kv. quality, while it was essentially the same for the two 200 kv. qualities.

In the fourth column the center doses resulting from cross-fire through limited phantoms are compared to those for the less heavily filtered 200 kv. radiation, and, in the fifth column, they are compared to the more heavily filtered 200 kv. radiation. For the thin section (12 cm.) the more

heavily filtered 200 kv. radiation not only shows a gain over the 1,000 kv. radiation but also a gain over the 200 kv. radiation filtered through 0.5 mm. of copper. The 1,000 kv. radiation value is less than either of the 200 kv. values. For the thicker sections, the depth dose is greater with 1,000 kv. and increases as the thickness increases. It is interesting to note that the depth dose is changing rapidly in the 200 kv. region. A slight change in filter causes gains which are an appreciable fraction of those resulting from the increase in kilovoltage to 1,000. In the region of 1,000 kv., we have found that it takes large changes in filter to produce even small changes in these cross-fire depth doses. If the 1,000 kv. radiation values are compared to those for 200 kv. filtered through 0.5 mm. of copper and used at 50 cm. target-skin distance, as in many clinics, the gain is very large.

The comparison, using fields of sizes other than 15 × 15 cm., is shown in Figure 6. For brevity, the results are given for the 200 kv. apparatus with the heavier filter only. Since the tube is excited by constant potential, the results are representative of those for as hard a quality of rays as is used ordinarily in this region.

COMPARATIVE DEPTH DOSES FROM 200 KV AND 1000 KV APPARATUS										
CONDITIONS 80 CM TSD			SINGLE-FIRE				CROSS-FIRE			
			PHANTOM LIMITED TO THICKNESS SPECIFIED				UNLIMITED PHANTOM		LIMITED PHANTOM	
"PRESDWOOD" PHANTOM SN FILTER ON 200 KV			MIDLINE CENTER % OF SURFACE	PERCENT GAIN BY 1000 KV	EXIT (AIR BEYOND) % OF SURFACE	PERCENT GAIN BY 1000 KV	MIDLINE CENTER % TOTAL SURFACE	PERCENT GAIN BY 1000 KV	MIDLINE CENTER % TOTAL SURFACE	PERCENT GAIN BY 1000 KV
THICKNESS	FIELD	KV								
12 CM	20X20	1000	71.4	4.2	38.8	56	100.6	−3.6	102.9	−6.5
		200	68.5		24.8		104.2		110	
	15X15	1000	70.9	9.0	38.2	65	100.6	−0.9	102 7	−2.7
		200	650		23.1		101.5		105.5	
	10X10	1000	681	13.0	36.6	77	98.9	+1.7	99.8	0 ↓
		200	60.2		20.7		97.3		99.8	
16 CM	20X20	1000	61.4	6.3	27.4	78	94.5	−1.1	96.3	−3.7
		200	57.7		15.4		95.5		100	
	15X15	1000	60.2	13.5	26.6	100	93.6	3.5	95.2	1.7 ↓
		200	530		13.3		90.5		93.6	
	10X10	1000	57.0	21	24.3	108	91.1	10.2	91.7	8.9
		200	47.0		11.7		82.7		84.3	
20 CM	20X20	1000	52.5	11.5	19.4	109	86.6	4.2	87.9	2.0 ↓
		200	47.1		9.3		83.1		86.1	
	15X15	1000	50.6	19	18.4	130	84.6	10.2	85.5	8.5
		200	42.6		8.0		76.8		78.9	
	10X10	1000	47.5	32	16.1	148	81.3	22	81.8	21
		200	36.0		6.5		66.6		67.6	
24 CM	20X20	1000	44.6	19	13.5	146	77.7	11.8	78.6	10.5
		200	37.5		5.5		69.5		71.2	
	15X15	1000	42.5	28	12.7	175	74.6	20	75.6	19
		200	33.2		4.6		62.2		63.5	
	10X10	1000	39.1	42	10.8	194	70.2	34.6	70.6	34
		200	27.4		3.7		52.2		52.8	

Fig. 6. A chart comparing the mid-line center depth doses resulting from single-fire and cross-fire through phantoms of several thicknesses with the 200 and 1,000 kv. apparatus using several sizes of fields.

The column for single-fire through phantoms of the thicknesses specified shows that for each field and thickness the 1,000 kv. radiation gives a greater mid-line center dose than the 200 kv., the gain increasing down the column toward smaller fields and greater thicknesses. The same is true for the exit dose except that the gain by 1,000 kv. radiation on the exit surface is very much greater in each case.

A study of the cross-fire data in Figure 6 reveals the following: (1) Using a limited phantom the gain by the 1,000 kv. radiation is less than that indicated by values

from an unlimited phantom, the difference in any case not amounting to more than a few per cent and becoming negligible at great thicknesses. (2) For large fields and comparative thinness, the 1,000 kv. values taken relative to the skin are even less than for the 200 kv. Such cases are seldom encountered in practice and consequently are of little clinical importance. Moreover, as previously noted, the negative values do not represent a real disadvantage but arise from the fact that, for these cases, the maximum doses do not occur on the skin but at short distances below the surface. Actually the distribution is more uniform when 1,000 kv. radiation is used for these cases but the differences are so small that no appreciable advantage is to be gained. (3) Appreciable advantage in depth dose can be gained with 1,000 kv. radiation only when thicker sections or smaller fields are to be used than for the conditions noted by the arrows in the last column.

CONCLUSIONS

It is thus concluded that, if the measurements we have described are a fair approximation to the relative effects to be produced on tissue, there is little advantage to be gained using the radiation from the 1,000 kv. apparatus in direct cross-fire through a section (1) 12 cm. thick, unless fields smaller than 10 × 10 cm. are to be used; (2) 16 cm. thick, unless fields smaller than 15 × 15 cm. are to be used; (3) 20 cm. thick, unless fields smaller than 20 × 20 cm. are to be used.

Extending these results to cases of multiple beams, we can point out that, because of the large exit doses with 1,000 kv. radiation, the overlapping of exit fields must be minimized in order to realize the largest gain.

We have considered many physical factors capable of changing these results, such as the effects of collimating devices, the presence of "cold" emission at 1,000 kilovolts, the type of ionization chamber used, and the use of even higher voltages, but the observations of the clinician, as presented by Dr. Stone (3), show that the effects of these finer details are often beyond clinically observable importance. It would seem that with either the 200 kv. or the 1,000 kv. apparatus, an irradiation technic can be devised to apply enough dosage internally to cause permanent damage to normal tissues surrounding a neoplasm without producing excessive damage to the skin. The physical difference in the technics for the two voltages is that for small tumors or thick body sections, less volume of tissue need be irradiated if 1,000 kv. radiation is used to produce a desired internal effect; further, because of the larger output obtainable in the range of 1,000 kv., the technic for irradiating can be carried out in a time that is clinically practicable. Whether or not these advantages are sufficient to justify the installation of an apparatus which can operate above 200 kv. remains to be seen.

Beyond these physical considerations the problems are mainly those of the biologist and clinician. The physicist should be consulted, however, concerning the comparability of the conditions under which the comparison of the effects of different factors such as filters, target–skin distance, or kilovoltage is to be made. Changes in such physical factors often result in changes in the prolongation and protraction of the doses administered to the skin or tumor and may be of more consequence in changing the observed clinical effects than any differences in voltage.

We wish to express our appreciation for the interest and co-operation of Robert S. Stone, M.D., Professor of Roentgenology, University of California Medical School, in whose department these studies were made.

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CASE REPORT

CALCIFIED EPIPLOIC APPENDAGES: A RADIOLOGICAL CURIOSITY

By ROBERT P. BARDEN, M.D., D.Sc. (Med.), *Pittsburgh, Pa.*

From the Department of Roentgenology, Allegheny General Hospital

The epiploic appendages of the colon have long been an anatomical curiosity. In 1863, Virchow (1) first described the formation of foreign bodies in the abdomen from these calcified appendages. In 1924, Klingenstein (2) noted that 12 cases of such foreign bodies had been described in the literature. Rankin, any interference with blood supply, the fat of the appendage is saponified and subsequently calcified, and the whole structure separates from its attachment to lie free in the abdomen.

The contemporary radiologic literature contains no reference to these fortuitous foreign bodies. Recently, two patients with these calcifications were seen within two months, indicating that the condition may be more common than recognized. At the time of operation for carcinoma of the rectum, one of these patients had a free calcified foreign body in the pelvis. This had not been demonstrated on the films made after a barium enema. The second patient illustrates that these calcifica-

Fig. 1. Anteroposterior view of the pelvis after inflation of the rectum with air. The two calcified shadows are in the positions which they occupied on most of the examinations. The possibility of ureteral, seminal vesicle, bladder, or rectal calculi had to be excluded.

Bargen, and Buie (3) devote an entire chapter in their text-book to diseases of the epiploic appendages. Occasionally torsion or embolism of one of these structures produces a surgical emergency. In 1933, Patterson (4) reviewed the literature and discussed the derivation of calcified appendiceal foreign bodies. Following

tions are not only radiologic curiosities, but can influence the differential diagnosis.

CASE REPORT

A. P., white male, aged 20 years, was admitted complaining of severe abdominal pain, nausea and vomiting of a few hours' duration.

Fig. 2. Lateral view of the pelvis after inflation of the rectum with air. The two calcified shadows are either in or adjacent to the rectum. Enemas did not alter their positions.

Physical examination showed local tenderness in the right lower quadrant, slight fever, and leukocytosis. There was no muscle spasm. The picture was somewhat complicated by the finding of right costo-vertebral tenderness and pus in the catheterized specimen of urine.

A flat film of the abdomen (Fig. 1) showed two oval calcifications in the right side of the pelvis near the line of the ureter. These did not have the usual characteristics of ureteral calculi.

The patient's acute symptoms subsided, and he received expectant treatment for several days. A lateral view of the pelvis (Fig. 2) showed the two calcifications, previously described, to be well posterior. It was then thought they were in the rectum. They could not be felt by the palpating finger or dislodged by enemas.

Fig. 3. Anteroposterior view of the pelvis after cystoscopy and catheterization of the ureters. The two calcified shadows are now widely separated. Neither was seen in the bladder.

Cystoscopic examination revealed a normal bladder with some pus coming from the right ureter. Roentgenograms made with the ureteral catheters in place (Fig. 3) showed the two calcifications now widely separated in the pelvis. They were not in the bladder or ureters.

Five days after admission laparotomy was performed and a subacute, retrocecal appendix was removed. At the same time two oval calcified foreign bodies were found, free in the pelvis. These corresponded to the shadows on the roentgenograms. There was enough partially saponified fat adherent to them to justify the pathologic diagnosis of calcified epiploic appendages.

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NOTES OF INTEREST

Members who missed the following excerpt from the **Berlin** letter appearing in the October 21 issue of the *Jour. Am. Med. Assn.* should find it of interest:

"Professor Lehmann, of Rostock, treated the problem of the relations of surgical clinics and x-ray institutes. Roentgenology is not a separate specialty but a medical ally. The type of men who are merely roentgenologists will disappear. X-ray institutes conducted independently easily lose contact with the clinics and yet the work done in the x-ray laboratory is part and parcel of the work done in the clinics. The directors of x-ray divisions should be members of the clinical staffs. He admitted the great difficulties of an organizational nature. For special examinations such as those of pyelography, ventriculography, and myelography, the ward system of hospitals with central x-ray institutes was not practical. Roentgenologists should not by themselves determine indications. Lehmann thinks that the x-ray department of a hospital should be in charge of a roentgenologist who is subject to the director of the surgical division. This position was challenged by the chairman of the society of German roentgenologists, who stated that the greatest importance was attached to close co-operation but that the problems discussed by Lehmann were still too unclarified to permit the roentgenologists to make a final decision."

* * *

For the past several years certificates of specialty have been issued by the New York County Medical Society through its "Special Committee on Radiology" to **New York** radiologists meeting the committee's requirements. By action taken at a recent meeting, the Society will, after this year, issue certificates only to roentgenologists and radiologists who have been certified by the American Board of Radiology.

* * *

The Committee on Ethics of the **Nassau County Medical Society**, New York, recently mailed a bulletin to all members, calling their attention to certain items in the code of ethics, and decrying the patronage of commercial x-ray and pathological laboratories by some members. The bulletin also called attention to the fact that the group hospitalization plan was being abused by "admissions for diagnostic purposes only."

* * *

Announcement was made by the Blue Cross Hospitalization Plan of **Boston** on September 12, that x-ray would be removed from the benefits offered under the Plan. The announcement came after less than a year of experiment with radiology included as a hospital benefit. Previously the Plan had confined its benefits to hospital services alone. Administrators of the Plan returned to the former status because "there have been abuses of the service and misuse of x-ray benefits."

* * *

The following is from *The New York Medical Week*, published by the **Medical Society of the County of New York:**

"Hereafter *Medical Week* will not publish advertisements of any commercial laboratories. This is done in the interest of practising pathologists, bacteriologists, radiologists and others who make of laboratory work a professional career as a specialty in medicine.

"Laboratories, even those run by medical men, which are purely commercial in nature or connected directly or indirectly with commercial enterprises, will hereafter not be featured in our advertising columns."

* * *

The **New Jersey Medical Society** has joined the societies of California, Wisconsin, District of Columbia, and Michigan in the launching of a medically controlled sickness insurance plan. Payment to physicians and surgeons renderi[illegible] service to subscribers in California and Michigan will be on a unit basis. In New J[illegible] where subscriptions will cost approximat[illegible] four cents a day, physicians will be paid [illegible] reduced fee schedule. The Medical Societ[illegible] Pennsylvania is preparing a plan, the de[illegible] of which have not been finally decided [illegible]

* * *

The extension of the functions of the [illegible]pital into the practice of medicine is pr[illegible] by a recent announcement by the W[illegible] Pennsylvania Hospital of **Pittsburgh.** [illegible]tients wishing to take advantage of [illegible] hospital offers a flat rate *per diem* pl[illegible] includes not only hospital accomm[illegible] services of a pathologist, a r[illegible] anesthetist, and metabolism and elec[illegible]graphic examinations. One day's ho[illegible]tion in a semi-private room will cost [illegible]

The following resolution was adopted at the recent annual meeting of the Medical Association of Georgia:

"WHEREAS: It is the studied opinion of most physicians that it is in the public interest that the practice of medicine be carried on by individual physicians and not by institutions, and

"WHEREAS: It has been brought to the attention of the Medical Association of Georgia in resolutions presented by the Georgia Radiological Society, that certain institutions in Georgia are practising medicine in that they are providing radiologic services to patients, both hospitalized and non-hospitalized, for a pecuniary consideration and to the financial detriment of private practitioners, and

"WHEREAS: Such practice has been condemned by the American Medical Association whose code of ethics provides that it shall be unethical for a physician to dispose of his services to a corporation or other organization in such a manner that such organization shall realize a profit from his professional activities, and

"WHEREAS: The Medical Association of Georgia has been memorialized by the Georgia Radiological Society to take remedial measures in this matter, therefore,

"BE IT RESOLVED by the House of Delegates of the Medical Association of Georgia, that we endorse the position of the American Medical Association on the above question, and

"That we authorize the Committee on Medical Defense of the Medical Association of Georgia, on complaint of any member of the Medical Association of Georgia residing in an area where practices above described are said to exist, and where such practices are detrimental to the financial interest of private physicians, to investigate such complaint and to use the instrumentalities of the Medical Association of Georgia to correct any unfair practice which may be found to exist."

* * *

One of the most interesting exhibits at the Hall of Science in San Francisco's Golden Gate Exposition was one entitled "Magic Shadows" which was prepared by the Pacific Roentgen Club. The difference between photography and radiography is demonstrated in the exhibit and illustrations are provided of the uses of x-ray in the study of anatomy, in obstetrics, pediatrics, oncology, and the industrial diseases.

* * *

The Section on Radiology of the Wisconsin State Medical Society has been conducting a vigorous campaign to protect the specialty of radiology in connection with a proposed hospital insurance plan now in the process of formation. An act enabling the formation of group hospitalization plans, sponsored by the State Medical Society, passed the Wisconsin legislature at its last session and was signed by the governor. The law provides that such plans "shall provide for hospital services only and shall not embrace medical services."

Despite this clear provision in the law, efforts are being made in certain directions to include radiology as a part of hospital care among the benefits offered by the plan. While disapproving of their inclusion as a violation of the law, the Council of the Wisconsin State Medical Society has agreed that radiology and pathology may be included as benefits if provided "on a cash basis over and above the *per diem* return to the hospital." The Section on Radiology has not withdrawn its demands for the complete exclusion of radiology.

MAC F. CAHAL
Executive Secretary

RADIOLOGICAL SOCIETIES IN THE UNITED STATES

Editor's Note.—Will secretaries of societies please co-operate with the Editor by supplying him with information for this section? Please send such information to Leon J. Menville, M.D., 1201 Maison Blanche Bldg., New Orleans, La.

CALIFORNIA

California Medical Association, Section on Radiology.—*Chairman,* Karl M. Bonoff, M.D., 1930 Wilshire Blvd., Los Angeles; *Secretary,* Carl D. Benninghoven, M.D., 95 S. El Camino Real, San Mateo.

Los Angeles County Medical Association, Radiological Section.—*President,* E. N. Liljedahl, M.D., 1322 North Vermont Ave., Los Angeles; *Vice-president,* M. L. Pindell, M.D., 678 South Ferris Ave.; *Secretary,* Wilbur Bailey, M.D., 2007 Wilshire Blvd.; *Treasurer,* Henry Snure, M.D., 1414 South Hope Street. Meets every second Wednesday of each month at County Society Building.

Pacific Roentgen Club.—*Chairman,* Karl M. Bonoff, M.D., Los Angeles; *Members of Executive Committee,* I. S. Ingber, M.D., A. C. Siefert, M.D., D. R. MacColl, M.D.; *Secretary-Treasurer,* L. Henry Garland, M.D., 450 Sutter St., San Francisco. Executive Committee meets quarterly; Club meets annually during annual session of the California Medical Association.

San Francisco Radiological Society.—*Secretary,* L. H. Garland, M.D., 450 Sutter Street. Meets monthly on first Monday at 7:45 P.M., alternately at Toland Hall and Lane Hall.

COLORADO

Denver Radiological Club.—*President,* F. B. Stephenson, M.D., 452 Metropolitan Bldg.; *Vice-president,* K. D. A. Allen, M.D., 452 Metropolitan Bldg.; *Secretary,* E. A. Schmidt, M.D., 4200 E. Ninth Ave.; *Treasurer,* H. P. Brandenburg, M.D., 155 Metropolitan Bldg. Meets third Tuesday of each month at homes of members.

CONNECTICUT

Connecticut State Medical Society, Section on Radiology.—*Chairman,* Samuel M. Atkins, M.D., 63 Central Ave., Waterbury; *Secretary-Treasurer,* Max Climan, M.D., 242 Trumbull St., Hartford. Meetings twice annually in May and September.

DELAWARE

Affiliated with Philadelphia Roentgen Ray Society.

FLORIDA

Florida Radiological Society.—*President,* H. B. McEuen, M.D., Jacksonville; *Vice-president,* Joseph H. Lucinian, M.D., Miami; *Secretary-Treasurer,* John N. Moore, M.D., 210 Professional Bldg., Ocala. Meetings held in November and at the annual meeting of the Medical Association of Florida in the spring

GEORGIA

Georgia Radiological Society.—*President,* James J. Clark, M.D., Doctors Bldg., Atlanta; *Vice-president,* L. P. Holmes, M.D., University Hospital, Augusta; *Secretary-Treasurer,* Robert C. Pendergrass, M.D., Prather Clinic, Americus. Meetings twice annually, in November and at the annual meeting of the Medical Association of Georgia in the spring.

ILLINOIS

Chicago Roentgen Society.—*President,* Roe J. Maier, M.D.; *Vice-president,* Adolph Hartung, M.D.; *Secretary,* Chester J. Challenger, M.D., 3117 Logan Blvd. Meetings the second Thursday of each month from October to May, except December, at the Hotel Sherman.

Illinois Radiological Society.—*President,* Cesare Gianturco, M.D., 602 W. University Ave., Urbana; *Vice-president,* Fred H. Decker, M.D., 802 Peoria Life Bldg., Peoria; *Secretary-Treasurer,* Edmund P. Halley, M.D., 968 Citizens Bldg., Decatur. Meetings quarterly by announcement.

Illinois State Medical Society, Section on Radiology.—The next meeting will be in Peoria, May 21–23, 1940. The officers are: *Chairman,* Warren W. Furey, M.D., 6844 Oglesby Ave., Chicago; *Secretary,* Harry W. Ackemann, M.D., 321 W. State St., Rockford.

INDIANA

The Indiana Roentgen Society.—*President,* Juan Rodriguez, M.D., 2902 Fairfield Ave., Fort Wayne; *President-elect,* H. H. Inlow, M.D., Shelbyville; *Vice-president,* Wemple Dodds, M.D., Crawfordsville; *Secretary-Treasurer,* Clifford C. Taylor, M.D., 23 E. Ohio St., Indianapolis. Annual meeting in May.

IOWA

The Iowa X-ray Club.—Holds luncheon and business meeting during annual session of Iowa State Medical Society.

KENTUCKY

Kentucky Radiological Society.—*President,* D. B. Harding, M.D., Lexington; *Vice-president,* I. T. Fugate, M.D., Louisville; *Secretary-Treasurer,* Joseph C. Bell, M.D., 402 Heyburn Bldg., Louisville. Meeting annually in Louisville, third Sunday afternoon in April.

MAINE

See New England Roentgen Ray Society.

MARYLAND

Baltimore City Medical Society, Radiological Section.—*Chairman,* Whitmer B. Firor, M.D., 1100 N. Charles St.; *Secretary,* Walter L. Kilby, M.D., 101 W. Read St. Meetings third Tuesday of each month.

MASSACHUSETTS

See New England Roentgen Ray Society.

MICHIGAN

Detroit X-ray and Radium Society.—*President,* Sam W. Donaldson, M.D., 326 N. Ingalls St., Ann Arbor;

Vice-president, Clarence Hufford, M.D., 421 Michigan Ave., Toledo, Ohio; *Secretary-Treasurer*, E. R. Witwer, M.D., Harper Hospital, Detroit. Meetings first Thursday of each month from October to May, inclusive, at Wayne County Medical Society club rooms, 4421 Woodward Ave.

Michigan Association of Roentgenologists.—President, C. K. Hasley, M.D., 1429 David Whitney Bldg., Detroit; *Vice-president*, M. R. Cooley, M.D., Mercy Hospital, Jackson; *Secretary-Treasurer*, C. S. Davenport, M.D., 609 Carey St., Lansing. Meetings quarterly by announcement.

MINNESOTA

Minnesota Radiological Society.—President, Leo G. Rigler, M.D., University Hospital, Minneapolis; *Vice-president*, Harry M. Weber, M.D., Mayo Clinic, Rochester; *Secretary*, John P. Medelman, M.D., 572 Lowry Medical Arts Bldg., St. Paul. These officers will assume their duties after the Summer meeting which will be held in connection with the Minnesota State Medical Society, May 31 to June 2, 1939.

MISSOURI

The Kansas City Radiological Society.—President, L. G. Allen, M.D., 907 N. 7th St., Kansas City, Kansas; *Secretary*, Ira H. Lockwood, M.D., 306 E. 12th St., Kansas City, Mo. Meetings last Thursday of each month.

The St. Louis Society of Radiologists.—President, Paul C. Schnoebelen, M.D.; *Secretary*, W. K. Mueller, M.D., University Club Bldg. Meets on fourth Wednesday of October, January, March, and May, at a place designated by the president.

NEBRASKA

Nebraska Radiological Society.—President, Roy W. Fouts, M.D., 1007 Medical Arts Bldg., Omaha; *Secretary*, D. Arnold Dowell, M.D., 816 Medical Arts Bldg., Omaha. Meetings first Wednesday of each month at 6 P.M. in Omaha or Lincoln.

NEW ENGLAND ROENTGEN RAY SOCIETY

(Maine, New Hampshire, Vermont, Massachusetts, and Rhode Island.) *President*, Langdon T. Thaxter, M.D., Maine General Hospital, Portland, Maine; *Secretary*, Aubrey O. Hampton, M.D., Massachusetts General Hospital, Boston. Meetings third Friday of each month from October to May, inclusive, usually at Boston Medical Library.

NEW HAMPSHIRE

See New England Roentgen Ray Society.

NEW JERSEY

Radiological Society of New Jersey.—President, P. S. Avery, M.D., Middlesex Hospital, New Brunswick; *Vice-president*, J. G. Boyes, M.D., 912 Prospect Ave., Plainfield; *Treasurer*, H. A. Vogel, M.D., 1060 E. Jersey St., Elizabeth; *Secretary*, W. James Marquis, M.D., 198 Clinton Ave., Newark; *Counsellor*, A. W. Pigott, M.D., Skillman. Meetings at Atlantic City at time of State Medical Society, and Midwinter in Newark as called by president.

NEW YORK

Associated Radiologists of New York, Inc.—President, Henry A. Barrett, M.D., 140 East 54th St., New York City; *President-elect*, I. J. Landsman, M.D., 910 Grand Concourse, New York City; *Vice-president*, Frederic E. Elliott, M.D., 122 76th St., Brooklyn; *Treasurer*, Solomon Fineman, M.D., 133 East 58th St., New York City; *Secretary*, William J. Francis, M.D., 210 Fifth Ave., New York City. Regular meetings the first Monday evening of the month in March, May, October, and December.

Brooklyn Roentgen Ray Society.—President, A. L. L. Bell, M.D., Long Island College Hospital, Henry, Pacific, and Amity Sts.; *Secretary-Treasurer*, L. J. Taormina, M.D., 1093 Gates Ave. Meetings first Tuesday in each month at place designated by president.

Buffalo Radiological Society.—President, Chester D. Moses, M.D., 333 Linwood Ave.; *Vice-president*, Edward C. Koenig, M.D., 100 High St.; *Secretary-Treasurer*, Joseph S. Gian-Franceschi, M.D., 610 Niagara St. Meetings second Monday evening each month, October to May, inclusive.

Central New York Roentgen Ray Society.—President, Jesse Randolph Pawling, M.D., 305 Clinton St., Watertown; *Vice-president*, Albert Lenz, M.D., 613 State St., Schenectady; *Secretary-Treasurer*, Carlton F. Potter, M.D., 425 Waverly Ave., Syracuse. Meetings are held in January, May, and October, as called by Executive Committee.

Long Island Radiological Society.—President, Samuel G. Schenck, M.D., Brooklyn; *Vice-president*, G. Henry Koiransky, M.D., Long Island City; *Secretary*, Marcus Wiener, M.D., 1430 48th St., Brooklyn; *Treasurer*, Louis Goldfarb, M.D., 608 Ocean Ave., Brooklyn. Meetings fourth Thursday evening each month at Kings County Medical Bldg.

New York Roentgen Society.—President, Harry M. Imboden, M.D., 30 W. 59th St., New York City; *Vice-president*, Henry K. Taylor, M.D., 667 Madison Ave., New York City; *Secretary*, Roy D. Duckworth, M.D., 170 Maple Ave., White Plains, N. Y.; *Treasurer*, Eric J. Ryan, M.D., St. Luke's Hospital, New York City.

Rochester Roentgen-ray Society.—Chairman, Joseph H. Green, M.D., 277 Alexander St.; *Secretary*, S. C. Davidson, M.D., 277 Alexander St. Meetings at convenience of committee.

NORTH CAROLINA

Radiological Society of North Carolina.—President, Robert P. Noble, M.D., 127 W. Hargett St., Raleigh; *Vice-president*, A. L. Daughtridge, M.D., 144 Coast

Line St., Rocky Mount; *Secretary-Treasurer*, Major I. Fleming, M.D., 404 Falls Road, Rocky Mount. Meetings with State meeting in May, and meeting in October.

OHIO

Cleveland Radiological Society.—President, J. H. West, M.D., 10515 Carnegie Ave.; *Vice-president*, Harry Hauser, M.D., City Hospital; *Secretary-Treasurer*, H. A. Mahrer, M.D., 10515 Carnegie Ave. Meetings at 6:30 P.M. at the Mid-day Club, in the Union Commerce Bldg., on fourth Monday of each month from October to April, inclusive.

Radiological Society of the Academy of Medicine (Cincinnati Roentgenologists).—*President*, Archie Fine, M.D., 707 Race St., Cincinnati; *Secretary-Treasurer*, Justin E. McCarthy, M.D., 707 Race St., Cincinnati, Ohio. Meetings held third Tuesday of each month.

PENNSYLVANIA

Pennsylvania Radiological Society.—President, Louis A. Milkman, M.D., Medical Arts Bldg., Scranton; *First Vice-president*, James E. Ginter, M.D., Dubois; *Second Vice-president*, Alexander Stewart, M.D., Shippensburg; *Secretary-Treasurer*, L. E. Wurster, M.D., 416 Pine St., Williamsport; *President-elect*, Harvey N. Mawhinney, M.D., 6546 Darlington Road, Pittsburgh; *Editor*, William E. Reiley, M.D., Clearfield; *Assistant Editor*, Sydney J. Hawley, M.D., Danville.

The Philadelphia Roentgen Ray Society.—President, Joseph E. Roberts, Jr., M.D., 403 Cooper St., Camden, N. J.; *Vice-president*, Jacob H. Vastine, M.D., Medical Arts Bldg., Philadelphia; *Secretary*, Barton R. Young, M.D., Temple University Hospital, Philadelphia; *Treasurer*, Fay K. Alexander, M.D., Chestnut Hill Hospital, Philadelphia. Meetings held first Thursday of each month at 8:15 P.M., from October to May in Thomson Hall, College of Physicians, 21 S. 22nd St., Philadelphia.

The Pittsburgh Roentgen Society.—President, Zoe A. Johnston, M.D., 601 Jenkins Arcade; *Vice-president*, Prentiss A. Brown, M.D., and *Secretary-Treasurer*, Harold W. Jacox, M.D., 4800 Friendship Ave. Meetings held second Wednesday of each month at 4:30 P.M., from October to June at various hospitals designated by program committee.

RHODE ISLAND

See New England Roentgen Ray Society.

SOUTH CAROLINA

South Carolina X-ray Society.—President, Percy D. Hay, Jr., M.D., McLeod Infirmary, Florence; *Secretary-Treasurer*, Hillyer Rudisill, Jr., M.D., Roper Hospital, Charleston. Meetings in Charleston on first Thursday in November, also at time and place of South Carolina State Medical Association.

SOUTH DAKOTA

Meets with Minnesota Radiological Society.

TENNESSEE

Memphis Roentgen Club.—Chairmanship rotates monthly in alphabetical order. Meetings second Tuesday of each month at University Center.

Tennessee Radiological Society.—President, Steve W. Coley, M.D., Methodist Hospital, Memphis; *Vice-president*, Eugene Abercrombie, M.D., 305 Medical Arts Bldg., Knoxville; *Secretary-Treasurer*, Franklin B. Bogart, M.D., 311 Medical Bldg., Chattanooga. Meeting annually with State Medical Society in April.

TEXAS

Texas Radiological Society.—President, Jerome H. Smith, M.D., San Antonio; *President-elect*, C. F. Crain, M.D., Corpus Christi; *First Vice-president*, M. H. Glover, M.D., Wichita Falls; *Second Vice-president*, G. D. Carlson, M.D., Dallas; *Secretary-Treasurer*, Henry C. Harrell, M.D., 517 Pine St., Texarkana. Meets annually. Temple is place of next meeting, Oct. 20 and 21, 1939.

VERMONT

See New England Roentgen Ray Society.

VIRGINIA

Radiological Society of Virginia.—President, Fred M. Hodges, M.D., 100 W. Franklin St., Richmond; *Vice-president*, L. F. Magruder, M.D., Raleigh and College Aves., Norfolk; *Secretary*, V. W. Archer, M.D., University of Virginia Hospital, Charlottesville.

WASHINGTON

Washington State Radiological Society.—President, H. E. Nichols, M.D., Stimson Bldg., Seattle; *Vice-president*, George Cornett, M.D., Yakima; *Secretary-Treasurer*, Kenneth J. Holtz, M.D., American Bank Bldg., Seattle. Meetings fourth Monday of each month at College Club, Seattle.

WISCONSIN

Milwaukee Roentgen Ray Society.—President, H. W. Hefke, M.D.; *Vice-president*, Frederick C. Christensen, M.D.; *Secretary-Treasurer*, Irving I. Cowan, M.D., Mount Sinai Hospital, Milwaukee. Meets monthly on first Friday at the University Club.

Radiological Section of the Wisconsin State Medical Society.—Secretary, Russel F. Wilson, M.D., Beloit Municipal Hospital, Beloit. Two-day annual meeting in May and one day in connection with annual meeting of State Medical Society, in September.

University of Wisconsin Radiological Conference.—Secretary, E. A. Pohle, M.D., 1300 University Ave., Madison, Wis. Meets every Thursday from 4 to 5 P.M., Room 301, Service Memorial Institute.

EDITORIAL

LEON J. MENVILLE, M.D., *Editor*

HOWARD P. DOUB, M.D., *Associate Editor*

THE RADIOLOGIST CHALLENGES THE FUTURE OF MEDICINE

If we view the hosts of organized medicine as an army attacking disease, then we might carry the simile further and suggest that as in the military arena we have, and are, witnessing immense changes in organization and maneuver, so we might parallel the necessity of drastic re-organization and modernization in our warfare against disease.

Where to-day are the glittering armies which marched in close formation to the attack; the cavalry with lances forward and colors flying? The romance of warfare has fled, and the victory of the future lies in the scientific modernizing of our armies into a co-ordinated whole. This transition has been difficult; grudgingly the army accepted the navy, and now, both are jealous of the growing influence of aviation, each trying to hold on to its alleged superiority, unwilling to recognize that perhaps the wars of to-morrow will all be fought in the air. Thorough adjustment and a new integration are necessary to make them effective.

I digress in this way because I feel that we have reached a very definite parallel in the field of medicine. The days when "gunshot" prescriptions held sway have long since passed and gone. The haste to resort to radical surgery is already looked at askance, and the autocratic medical dictator is no more popular with us than the European brand. The General Practitioner who served and is serving with such unstinted effort now has to take stock and see where he stands. The specialist and the clinic are here, and here to stay, and medicine now has to ask itself just what is the authority for its various judgments, and where, in the scheme of things, do we all stand. There is no place in the modern army that advances to attack disease for petty feeling and jealousies. Our work can be accomplished only by an honest recognition of the new forces that now contribute to our success. Just as the battles of the future cannot be won by an army looking with disdainful superiority upon the lusty infant, aviation, so we must adjust ourselves to the inevitable changes which radiology has brought to the fields of diagnosis and therapy.

The time has surely arrived when, in the interest of the public and for our own professional welfare, we should enter into a full-fledged partnership with the new methods that have proven of such inestimable value. The practitioner of the future may perhaps find the tables completely turned, and the authority will be from behind the fluorescent screen and film-viewing rooms in collaboration with the attending doctors. Results to-day show very clearly that the true welfare of the patient lies in a consulting room, with men who may have little to do with him, *per se*, directly, but whose judgments should be considered of vastly greater importance than they have been heretofore. Ofttimes, in office and hospital, we see specialists, whose findings are final, being treated as subordinates, as mere technicians to wait upon their confrérès.

When one thinks of the work of the skilled radiologist, and his experience with living pathology, which gives him far more reason to state the logical therapeutic approach, being treated as just an adjunct and by-product of medicine, one cannot help but feel that the public is suffering accordingly. The centralizing of the forces of medicine will see the day when the radiologist may perhaps be the co-ordinator and pivot upon which medical action will develop.

Keeping to the analogy I have used, radiology, like aviation, started almost as a novelty, and passed through many years of experimentation; its next advance was definitely limited to a dark room in the basement, the

radiologist as a technician at the beck and call of the profession. But to-day the picture has changed entirely, and its field is so extended that it now has to develop specialties within itself, and the radius of its work is of far-reaching importance. The radiologist is a practising physician, and it is clear that his position as consultant is of increasing value to both the patient and the medical profession in general. Therefore, his relationship to hospital governing bodies, to medical men on staffs, to insurance companies, and all corporate bodies should assure for him the same consideration as that given to all other physicians.

When we examine the field of cancer, we can immediately see how valuable is radiotherapy. In the early days it was confined to the treatment of superficial lesions, but by a process of growth it has become a necessity in the treatment of nearly all cases of cancer. By additions to his armamentarium of modern equipment, together with his opportunity to acquire a close-up of large numbers of neoplastic cases, the radiologist has acquired a special knowledge of tumors which now places him in a most advantageous position to be of service to all. The future of cancer control finds the radiologist in the very center of the management of all malignant cases.

Radiology has come a long way from the days of utter servility to the profession—when we were tossed hither and yon. The present day finds us penetrating what has always been considered the "preserves" of medical men in other fields, and, like the aviator, we have become a living necessity in modern life. It is certainly not the wish of the radiologist to trespass on and replace the work of the surgeon, the internist, and specialists in other branches, but along with the whole re-organization of medicine we need not be surprised if the radiologist becomes the key-man, co-ordinating the work in all fields.

Finally, it is only right that we should give adequate thought to the future, and if radiology is to continue to be the valuable aid that we are claiming, then key-men must be found—specially trained in every branch of our work, including intensive intern work. No medical man should be accepted by our teaching institutions to pursue the studies in radiology unless he has shown exceptional adaptability. It is in the interest of the profession in general, as well as the public, that we secure students who are the most outstanding men in their classes, with gifts necessary for this work, with the broadest kind of background, the ability for organization, the confidence of their confrérès, and the power of leadership necessary to co-ordinate all branches of the service, so that the public may be served most completely. The day of conflicting interests must go and a completely integrated profession take its place. The lusty infant, radiology, has grown up. It now depends upon ourselves as to what measure of service it shall be to mankind.

W. H. McGuffin, M.D.

ANNOUNCEMENT

DIRECTORY OF MEDICAL SPECIALISTS

The Advisory Board for Medical Specialties will issue in December the first edition of the Directory of Medical Specialists, listing approximately 14,000 specialists certified by the twelve American Boards and the two affiliate Boards in the Specialties.

This Directory will have three sections. The first will be devoted to a brief discussion of the Advisory Board for Medical Specialties, its organization and objectives. The second section will have fourteen separate divisions, one for each American Board with a geographic and a detailed biographic listing of its Diplomates. Each of these divisions will give full information regarding requirements for admission to examinations for certification, details of organization of each Board, and other general information. The third and final section will be a complete alphabetic list of all 14,000 Diplomates, with their addresses and indications of specialty certification.

It is expected to issue the Directory every two years. No charge is made for any listing in the Directory, and only the names of the specialists certified by the American Boards will be included.

The Directory is to be the official publication of the Advisory Board for Medical Specialties and will be issued through the Columbia University Press in New York City. Plans for the Directory have been under way for nearly three years. It represents an effort officially to inform the lay and medical public regarding the present strong movement for certification of qualified medical specialists, and is expected

to have wide use as a reference work in this respect.

Financial support has been given the Directory by the American Boards; the project is not designed to be profit-making, and the widest possible public distribution of the Directory is desired. On these accounts, the subscription price of the book has been set at a sum ($3.50 per copy) computed to cover only publication expenses.

The Directory should be invaluable to the entire medical profession in the reference of patients, as well as in many other ways, and the individual support of this new project of the American Boards is earnestly solicited of every Diplomate.

The Directory will be sold generally to physicians, libraries, hospitals, and others by subscription. Such subscriptions may be made through the Columbia University Press, 2960 Broadway, New York, N. Y., or through the office of the Directing Editor.

The Secretary of the American Board of Radiology wishes to urge that Diplomates of this Board and others interested in Radiology give their active support by subscribing to the Directory. This is direct support of the work of this, as well as of the other American Boards, as the Directory will be not only another strong instrument in the improvement of the standards of special medical practice in this country, but also constantly useful for reference in the office of any physician or hospital.

The Editorial Board consists of the secretaries of the fourteen American Boards. Dr. Paul Titus, 1015 Highland Building, Pittsburgh, Pa., Secretary of the Advisory Board, is the Directing Editor.

COMMUNICATION

CENTER FOR CONTINUATION STUDY, UNIVERSITY OF MINNESOTA

The University of Minnesota announced during the Summer that a three-day continuation course in neurologic radiology would be held at the Center for Continuation Study from Nov. 13 to 15, 1939. Enrollment was limited to radiologists and the course occupied the full time of those in attendance. Physicians residing outside the State of Minnesota were accepted on the same basis as residents.

The program follows:

Monday, November 13

Orientation, J. M. Nolte, Director of Center for Continuation Study; William A. O'Brien, M.D., Director of Department of Post-graduate Medical Education.

Anatomy of Brain, Skull, and Spine, A. T. Rasmussen, Ph.D., Professor of Anatomy; Leo G. Rigler, M.D., Professor of Radiology.

Pathology of Tumors of the Brain and Spinal Cord, James W. Kernohan, M.D., Professor of Pathology, Mayo Foundation.

Normal Encephalogram and Ventriculogram, Cornelius G. Dyke, M.D., Assistant Professor of Radiology, Columbia University College of Physicians and Surgeons.

Round Table: Intracranial Calcification, John D. Camp, M.D., Associate Professor of Radiology, Mayo Foundation; Merrill C. Sosman, M.D., Assistant Professor of Roentgenology, Harvard University Medical School; Cornelius G. Dyke, M.D.

Symposium—Brain Tumors: Clinical Aspects, J. Charnley McKinley, M.D., Professor of Nervous and Mental Diseases; Roentgenologic Aspects, Merrill C. Sosman, M.D.; Surgical Aspects, Winchell M. Craig, M.D., Professor of Neurosurgery, Mayo Foundation.

Tuesday, November 14

The Abnormal Encephalogram and Ventriculogram, Cornelius G. Dyke, M.D.

The Normal and Abnormal Sella, John D. Camp, M.D.

Meningiomas and Lesions of the Calvarium Including Fractures, Merrill C. Sosman, M.D.

Clinical-pathological Conference, W. T. Peyton, M.D., Associate Professor of Surgery; A. B. Baker, M.D., Assistant Professor of Nervous and Mental Diseases; Harold O. Peterson, M.D., Instructor in Radiology; Merrill C. Sosman, M.D.; Cornelius G. Dyke, M.D.; John D. Camp, M.D.

Symposium—Protruded Intervertebral Discs: Clinical Neurologic Aspects, M. N. Walsh, M.D., Fellow in Neurology, Mayo Foundation; Orthopedic Aspects, Harry B. Macey, M.D., Instructor in Orthopedic Surgery, Mayo Foundation; Roentgenologic Aspects, John D. Camp, M.D.; Surgical Aspects, J. Grafton Love, M.D., Assistant Professor of Neurosurgery, Mayo Foundation.

Wednesday, November 15

Radiologic Treatment of Gliomas and Pituitary Adenomas, Merrill C. Sosman, M.D.

Platybasia; Encephalography in Spastic,

Mentally Deficient, and Epileptic Children, Harold O. Peterson, M.D.

Roentgenologic Diagnosis and Localization of Lesions Affecting the Spinal Cord, John D. Camp, M.D.

Round Table—Film-reading and Outline of Technic, John D. Camp, M.D., and Harold O. Peterson, M.D.

BOOK REVIEWS

RÖNTGENPHYSIK (Roentgen Physics). By ADOLF LIECHTI, M.D., Professor of Medical Radiology and Director of the Roentgen Institute of the University of Bern, with contributions by WALTER MINDER, Ph.D., Technical Director of the Institute of the Radium Foundation in Bern. A volume of 308 pages, with 227 illustrations. Published by Julius Springer, Vienna, 1939. Price: R.M. 31.80.

"Without thorough knowledge of the physical principles radiology cannot be practised well," states the author in his foreword and, therefore, he undertook the preparation of this book which contains much physical data of interest and value to the radiologist.

The subject matter is well arranged and covers first the strictly physical aspect: Character and properties of rays of short wave length; roentgen rays and atomic structure, radio-activity, radiation absorption and scattering. The following two chapters are devoted to the construction of tubes and apparatus or what might be called the "engineering" problems. The effects of x-rays and gamma rays are also discussed, including physical, physical-chemical, chemical, and biologic effects as well as a brief analysis of several theories regarding their mode of action. The physical foundations of x-ray dosimetry are outlined in great detail, while a brief paragraph relates the measuring methods for beta and gamma rays of radium. The author also presents some of the principles of x-ray technic as, for instance, the fundamentals of projection, the use of diaphragms, kymography, tomography, stereoscopy, and methods for the determination of the thickness and density of an object. The concluding chapter deals with some of the non-medical uses of x-rays: the examination of paintings and materials as well as a brief description of x-ray patterns. The bibliography is chiefly limited to books and monographs or chapters in larger reference works.

The book is well illustrated and the many charts facilitate the understanding of the text greatly. It is written by a physician for physicians and, although complicated mathematical formulæ have been omitted, the accuracy of presentation seldom suffers. Liechti's "Roentgen Physics" is, therefore, heartily recommended.

A TEXTBOOK OF NEURO-RADIOLOGY. By CECIL P. G. WAKELEY, D.Sc., F.R.C.S., F.R.S.E., F.A.C.S., F.R.A.C.S. (Hon.), Fellow of King's College, London; Senior Surgeon, King's College Hospital and West End Hospital for Nervous Diseases; Consulting Surgeon to the Maudsley Hospital and to the Royal Navy; Hunterian Professor, Royal College of Surgeons of England, and ALEXANDER ORLEY, M.D., D.M.R.E., Fellow of the British Association of Radiologists; Radiologist, West End Hospital for Nervous Diseases; Assistant Radiologist, Margaret Street Hospital for Diseases of the Chest and Margaret Street X-ray Clinic, London. A volume of 336 pages, with 229 illustrations. Published by Williams & Wilkins Company, Baltimore, 1939. Price: $8.00.

There has been a lamentable need for an informative text concerning the subject of neuroroentgenology and the authors have compiled this text with the hope that it will fill this gap in the roentgenologic literature. Since there is no similar text for comparative purposes it must be said that any contribution along this line is a step ahead, nevertheless this book as an index of the usefulness of roentgenologic procedures in neurologic conditions is a sad disappointment.

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W. R. Brooksher, M.D., of Fort Smith, Ark.
Benjamin Copleman, M.D., of Perth Amboy, N. J.
Joseph T. Danzer, M.D., of Oil City, Penna.
Percy J. Delano, M.D., of Chicago, Ill.
Sydney J. Hawley, M.D., of Danville, Penna.
Eugene T. Leddy, M.D., of Rochester, Minn.
Lester W. Paul, M.D., of Madison, Wisc.
Ernst A. Pohle, M.D., Ph.D., of Madison, Wisc.
Simon Pollack, M.D., of St. Louis, Mo.
Jacob Sagel, M.D., of Gary, Ind.
Ernst A. Schmidt, M.D., of Denver, Colo.
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GYNECOLOGY AND OBSTETRICS

Hysterosalpingography in the Practice of Gynecology and Obstetrics. Antonio Taddei. Arch. di Radiol., 14, 421–449, July–October, 1938.

The author reports an investigation made in the Clinic of Pisa on 200 cases of sterility, discusses and illustrates the great value of hysterosalpingography, and adds an extensive bibliography.

E. T. Leddy, M.D.

Cesarian Section: An Analysis of 1,322 Cases, Josiah R. Eisaman and John M. Cook. Pennsylvania Med. Jour., 42, 885–888, May, 1939.

A critical analysis of Cesarian section indicates that the mortality may be as high as 10 per cent; the authors feel that operations done because of cephalopelvic disproportions are too numerous and suggest that critical roentgen pelvimetry be done as a means of more accurate measurement.

Joseph T. Danzer, M.D.

A New Roentgen Method in the Treatment of Climacteric Bleeding, Sparing the Ovaries. W. Schaefer and H. Huber. Strahlentherapie, 64, 557, 1939.

The authors relate their experience in the treatment of climacteric bleeding by means of intra-uterine x-ray therapy. The exposure takes only 66 minutes and the ovaries receive very little or practically no radiation. The special x-ray tube, with filter attached to permit fixation within the uterus during the treatment, is described and illustrated. At 2.5 cm. distance from the central ray, the dose amounts to approximately 200 r. So far, seven patients have been treated successfully and kept under observation for over one year and a half; the case histories are appended.

Ernst A. Pohle, M.D., Ph.D.

HEART AND VASCULAR SYSTEM

Chronic Constrictive Pericarditis with Calcification: Report of Case. Moses Barron. Minnesota Med., 22, 138, 139, February, 1939.

The patient, whose case is reported in this article, was referred with diagnosis of heart disease. She had swelling of the abdomen of two years' duration, weakness of one year's duration, loss of weight, inconstant edema of the legs, with symptoms so severe that she had been confined to bed for six months.

The heart was apparently not enlarged; there were pulsations in the neck; the lungs were clear; free fluid in the abdomen, and the liver was enlarged.

Roentgenogram showed the heart in mid-position with marked calcification of the pericardium. It appeared as if the heart were enclosed in a calcium shell. This was even more plainly evident in the lateral view. There was a florid cyanosis. History was negative for alcoholism.

Cirrhosis might have been considered had not the heart roentgenogram given evidence as heretofore described.

The symptoms are ascribable to the pericarditis. There is an "inflow stasis," an insufficient amount of blood is able to enter the heart chambers, which results in diminished output. A similar condition often results from tricuspid stenosis. X-ray examinations here give invaluable differentiation.

The treatment which offers the most benefit in these cases is decortication. This patient was referred to Owen Wangensteen, M.D., who performed this operation.

Dr. Wangensteen, in discussing the case, pointed out that the outstanding findings in making a diagnosis are increased venous pressure, indicated by prominence of the jugular and antebrachial veins at heart level, a low arterial pressure, and small pulse. He also mentioned, in answer to a question about the function of the heart after removal of the pericardium, that this operation has been done repeatedly in dogs which later show the same capacity for work on the treadmill as normal dogs.

The author emphasized, in closing, that 50 per cent of the patients receive definite benefit from the procedure.

Percy J. Delano, M.D.

Symptomless Pericarditis: Report of Two Cases. E. L. Rubin and M. H. Pappworth. British Jour. Radiol., 11, 671–675, October, 1938.

The case histories of two patients with pericarditis are given. Neither patient had any cardiac symptoms. One was a male, 26 years of age, who had suppurative joint and bone infections, with occasions during which he probably had septicemia. Roentgenograms of the heart showed an enormous pericardial effusion, which was present for about nine months. During this time he was doing manual work without cardiac symptoms.

The second case was that of a woman, aged 31, who showed marked calcified deposits in the pericardium. The patient was followed for four years, during which time she had no cardiac symptoms or signs.

S. J. Hawley, M.D.

HERNIA, DIAPHRAGMATIC

Two Cases of Diaphragmatic Hernia. H. G. Humphries. Australian and New Zealand Jour. Surg., 8, 308–310, January, 1939.

The author reports two cases of herniation of the left leaf of the diaphragm which present almost identical clinical and radiological findings but which proved to be of different types etiologically. The first case was that of a male, two and one-half years of age, who presented the history of recurrent attacks of vomiting of progressive severity and frequency, accompanied by severe pain. Roentgenograms with barium meal showed the lower two-thirds of the left chest to contain many loops of small intestine as well as the major portion of the ascending and transverse colon. The surgical approach was through the chest, and, at operation, the greater portion of the small and large bowel, as well

as the spleen, were found to be herniated into the left thoracic cavity through a defect 3.75 cm. in diameter. The left lung was collapsed and the heart displaced to the right. The patient did not recover from the shock and expired the first post-operative day.

The second patient was a four and one-half-year-old male who showed a cardiac pulsation on the right side as an incidental finding. Radiographic studies showed the stomach and splenic flexure in the lower half of the left chest cavity. However, the films reproduced in this article seem to show a definite arcuate curvature of the linear border to the upper surfaces of these structures, such as is not seen in those of the first case. At operation, it was discovered that there was a marked eventration of the left dome of the diaphragm which consisted of a thin ballooned flaccid pouch. No attempt at repair was made and the patient recovered uneventfully.

SIMON POLLACK, M.D.

Congenital Diaphragmatic Hernia of the Right Side. B. Kryński. Polski Przegl. Radiol., 13, 95–99, 1938.

The author presents three cases of right-sided diaphragmatic hernia which occurred in little children. In all three cases a portion of the transverse colon had passed through the Larrey fissure between the sternal and costal portions of the diaphragm.

ERNST A. SCHMIDT, M.D.

HERNIA, INGUINAL

Roentgen Diagnosis of Reducible Hernia. Carye-Belle Henle. Am. Jour. Roentgenol. and Rad. Ther., 40, 392–396, September, 1938.

This new method, which does not supplant but rather complements and refines the present means of diagnosis, should be of value in the debatable and unsuspected cases. It may also help to differentiate the types.

Technic.—Fluoroscopy, the better method, or film examination, is done when the small intestine is full on both sides, while the intra-abdominal pressure is at its greatest. Thus the examination should be made two hours after the ingestion of a meal or at other times, as the filling varies.

Diagnosis.—In the normal, the loops descend as a whole and maintain their relationship to each other. A slight bulge of the adjacent loop of intestine is noted at the site of a hernial weakness. In the presence of a hernia, a loop of intestine descends into the course of the hernia.

An indirect inguinal hernia shows the loop running first downward, then obliquely downward and inward. A direct hernia will bulge vertically above the middle of the obturator foramen and is wider than the indirect. In a femoral hernia, the protrusion is over the outer side of the symphysis pubis. In relaxation of the pelvic floor in women, the central intestinal loops dip deep over the symphysis pubis.

S. M. ATKINS, M.D.

INDUSTRIAL USES OF RADIATION

X-ray Methods in the Investigation of the Failure of Metals. H. J. Gough and W. A. Wood. British Jour. Radiol., 11, 479–488, July, 1938.

The authors review the outstanding problems in the failure of metals, particularly those points in which x-ray examinations and investigations of crystal structure are apt to be of assistance in the solution. These problems are illustrated by some recent investigations by x-rays of metals under static deformation and fatigue. There are many problems yet to be solved, but these investigations are establishing a systematic foundation for the solution of them.

S. J. HAWLEY, M.D.

The X-ray and Gamma-ray Protective Values of Building Materials. G. W. C. Kaye, W. Binks, and G. E. Bell. British Jour. Radiol., 11, 676–685, October, 1938.

The results of experiments to determine the lead equivalents of various concretes (ordinary and barium), bricks, and iron are given, over a voltage range from 100 to 400 kv. and for gamma radiation. These are presented in the form of graphs. The values rise to a maximum at about 100 kv., then fall to a minimum at 200 kv., and subsequently rise continuously. Protective values at higher voltages are deduced. As these deduced values agree well with experimental values between 200 and 400 kv., they are thought to be sufficiently correct for use for any medical requirements.

S. J. HAWLEY, M.D.

THE LIPS

Radiological Treatment of Carcinoma of the Lip. R. B. Engelstad. Strahlentherapie, 64, 571, 1939.

During the period 1932–1935, 147 cases of malignant tumors of the lip were examined and treated in the Norwegian Radium Hospital, at Oslo. Of these, 146 were carcinomas and one a sarcoma. The latter, which occurred in a one-year-old boy, was removed surgically, recurred, and was treated by radiation. The patient has been free from recurrence for six years. Among the patients with carcinoma were 132 men and 14 women. The average age was 67 years, the youngest patient being 22 and the oldest 91. In 143 instances, the lower lip was involved and the upper lip in only three.

The material is evaluated statistically in great detail and the results of the analysis are presented in 20 tables, which show the exact distribution as to age and severity of involvement, type of treatment received, relationship between metastases, and end-results. In analyzing his material, the author differentiates five stages: Stage 1.—Operable tumor without metastases; Stage 2.—Operable tumor with operable metastases; Stage 3.—Inoperable tumor without metastases; Stage 4.—Inoperable tumor with operable metastases, and Stage 5.—Operable or inoperable tumor with inoperable

metastases. It is shown beyond doubt that the percentage of cures drops rapidly with the degree of involvement. As a rule, the author prefers interstitial radium implantation, using 2 mg. radium needles filtered through 1 mm. Pt, inserted at approximately 0.75 cm. distance for a period of five days. This procedure is carried out under local anesthesia and does not bother the patient much. No serious infections have been observed. If the tumor is too large, teleradium therapy is given preference. A sufficient reaction is usually obtained after the application of from 40 to 45 Dominici units. The radium bomb used contains three grams radium element with a filter equivalent to 2 mm. Pt. If there are metastases in the lymph nodes or if there are suspicious lymph nodes, they are treated by x-ray therapy applied according to the protracted fractional dose method. If, two months after the last treatment, there should still be present suspicious lymph nodes, then surgical resection of such nodes is carried out. The patients were observed from three to six years. The following figures are the percentages of "freedom from symptoms," calculated at the time of publication: Stage 1, 79.5 per cent; Stage 2, 64 per cent; Stage 3, 25 per cent; Stage 4, 50 per cent, and Stage 5, 7 per cent.

In conclusion, the author states that radiological treatment of primary lip tumor is superior to surgery. He also stresses the point that the cosmetic result is far better after radiation therapy. The indications for the treatment of the lymph node metastases are much more complicated because radiation therapy quite frequently does not lead to a cure. If there are no palpable lymph nodes or nodes which do not seem suspicious, prophylactic irradiation has not, as a rule, been used in the author's series. He makes the provision, however, that check-up examinations should be given at regular intervals. Of the operable cases treated early by radiation therapy, 89 per cent were free from symptoms at the time of writing the report.

ERNST A. POHLE, M.D., Ph.D.

THE LUNGS

The Differential Diagnosis of the Pulmonary Lesions from the Roentgen Standpoint. Adolph Hartung. Illinois Med. Jour., **74**, 243–248, September, 1938.

According to the author, many diseases, especially pulmonary lesions, cannot be accurately diagnosed without the aid of the x-ray. He calls attention to the fact that pathologic changes give rise to density variations which can be detected more easily and more accurately by x-ray examination than by any other known method. On such an examination, residual changes show up and must be recognized so as not to confuse such shadows with those due to the present condition. He stresses the need for exposures at various angles, for repeated examinations, for the use of special procedures such as iodized oil injections, paracentesis, or pneumothorax. Such a procedure he believes to be especially applicable to subacute, post-operative, and chronic lung conditions.

WILLIS A. WARD, M.D.

Mixed Tumors of the Lung. Editorial. Jour. Am. Med. Assn., **111**, 1939, 1940, Nov. 19, 1938.

Benign and malignant tumors of the lung are now considered suitable for successful surgical excision with comparative safety and with a reasonable chance of cure. With the emphasis on early diagnosis has come the identification of the early clinical manifestations of these tumors. The symptoms produced by pulmonary tumors are now becoming more generally known. With the advent of bronchoscopy, their early stages are actually seen and biopsy specimens obtained and studied. Whereas knowledge of neoplasms of the lung was formerly based on necropsy material, now bronchoscopic examinations with study of biopsy specimen are more frequent. With this advance has come an apparent increase in the incidence of such lesions but with it a confusion as to their actual nature. Especially important is the estimation of the malignancy of these early tumors. On such a diagnosis must rest the decision as to the most appropriate type of therapy.

An anatomic and clinical study of many of these cases recently reported in the Ludwig Hekteon *Festschrift* by Womack and Graham presents evidence to show that many of the pulmonary neoplasms resemble fetal pulmonary tissue and arise from the failure of embryonic buds to develop into normal structures. Recognizing their similarity of behavior and in some respects their similarity of origin to the mixed tumors of the parotid gland, these workers have described this group of neoplasms as mixed tumors of the lung and have built up a histologic and clinical entity to fit their observations.

These tumors arise from entoderm and mesoderm and hence may take various forms, depending on the tissue they resemble. More important is the fact that these tumors, though at first benign, may eventually develop into carcinoma and are to be considered, therefore, as potentially malignant. By the time they do become malignant their pathogenesis is lost and they may look like the ordinary type of bronchiogenic carcinoma. Thus is explained the failure of postmortem studies to recognize this group of tumors. With the realization of their common origin as mixed tumors, Womack and Graham feel, on the basis of their studies, that such terms as adenocarcinoma, alveolar carcinoma, mucous gland carcinoma, "oat-cell" carcinoma, and round-cell carcinoma are now untenable. With this simplification in the terminology as well as pathogenesis, the study of the early manifestations of pulmonary neoplasms will be facilitated. Perhaps the growing incidence of the late stage of inoperable cancer of the lung may be halted by a recognition of the lesion which in many cases seems to be its precursor.

CHARLES G. SUTHERLAND, M.D.

The Healing of Cavities. W. Pagel and F. A. H. Simmonds. Jour. Am. Med. Sci., **197**, 281–286, March, 1939.

The usual methods of closure of cavities in pulmonary tuberculosis are: (1) the ingrowth of an epithelial lining after the tuberculous disease has been replaced by ordinary granulation tissue and fibrosis, and (2) approximation of the walls of the cavity, with the formation of a fistulous tract, or a strand of fibrous tissue, if closure is complete.

Occasionally, the caseous material within a cavity may show deposition of calcium salts as evidence of healing. Other factors influence this healing, notably the occlusion of the bronchus leading to the cavity by kinking due to pneumothorax, edema, granulation tissue, fibrous stenosis, or obstruction by a plug of caseous material.

The leukocytic zone about an area of acute infiltration, the zone of *precavernous demarcation*, may appear on a film as a nearly circular outline. Should the infection progress to caseation, its resemblance pathologically to the third named manner of cavity-healing is close. In a case described, what appeared to be cavities by x-ray examination were areas of liquefaction pathologically. It is speculated that cavities with thick caseous walls were collapsed, due to kinking of the bronchus, the approximated walls forming a solid caseous wall which liquefied.

BENJAMIN COPLEMAN, M.D.

Apical Lung Tumors: Further Observations, with Report of Seven Additional Cases. Justin J. Stein. Jour. Am. Med. Assn., **111**, 1612–1616, Oct. 29, 1938.

Pancoast designated malignant tumors of the thoracic inlet and pulmonary apex as apical chest tumors, in 1924, and, in 1932, he advised against the use of this name and described these as "superior pulmonary sulcus tumors."

The characteristic manifestations associated with tumors in the thoracic inlet, as described by Pancoast, were pain about the shoulder radiating down the arm, Horner's syndrome, atrophy of the muscles of the hand, and roentgenographic evidences of a small homogeneous shadow at the extreme apex of the lung. Evidence of local destruction of the ribs were always noted, and often infiltration into the adjacent vertebræ. Intrathoracic metastases were not noted. He did not believe that the tumor had its origin from the lung, pleura, ribs, or mediastinum; in fact, he stated that primary lung cancer could be practically ruled out. He suggested an embryonal rest as an etiologic factor.

In 12 of 15 cases studied, Stein found the histologic diagnoses made from specimens removed as squamous-cell carcinoma, six; adenocarcinoma, four; metastatic osteogenic sarcoma, one; undifferentiated carcinoma with areas simulating an adenocarcinoma, one.

In 14 of the 15 cases, the site of origin was definitely considered to be the terminal bronchioles of the lung. This was histologically confirmed in 12 of the 13 cases in which biopsy material was available. Metastatic lesions from carcinoma of the breast, kidney, or adrenal and from the stomach to the pulmonary apex have been reported as causing the Pancoast type of tumor; also, sarcoma of the thymus, sarcomas originating near the pulmonary apex, intrathoracic sympathoblastoma, and others. By far the majority of cases reported have been atypical carcinomas of the lung.

Stein's conclusions are that further evidence shows that the majority of malignant tumors located in the region of the thoracic inlet are carcinomas of the terminal bronchioles of the lung. The prognosis in this type of tumor is very poor; the average duration of life from the onset of symptoms in his series of 12 deceased patients was 13.1 months. Because of the location of these tumors in the thoracic inlet and their mode of extension to the brachial plexus and inferior cervical ganglion, surgery is not indicated. Not one patient in his series received any appreciable relief from pain following radiation therapy. Since severe pain about the shoulder radiating down the arm on the affected side is practically the first symptom in all cases, patients thus afflicted should be carefully examined for the other manifestations associated with these tumors in order to rule out a so-called superior pulmonary sulcus tumor. Because of the symptoms, patients having apical lung tumors are generally given a diagnosis of tuberculosis, neuritis, or arthritis before a tumor is suspected.

CHARLES G. SUTHERLAND, M.D.

NASOPHARYNX

Malignant Neoplasms of the Nasopharynx. A. C. Furstenberg. Surg., Gynec. and Obst., **66**, 400–404, Feb. 15, 1938.

While the cause of these tumors is not known, certain clinical manifestations are of interest. They show a striking tendency to infiltrate upward, erode bone, and eventually disturb those structures which pass through the basal foramina. There is early lymphatic metastasis in the posterior cervical chain, while there is extension by continuity of tissue to the base of the skull. Seldom does the lesion progress downward along the lateral pharyngeal wall. An early symptom is pain vaguely referred to the posterior nares, or down along the pharynx, or into the ear, usually sharp in character but intermittent. There is usually a sense of discomfort within the ear. The first evidence of the disease, in 60 per cent of the author's 40 cases, was swollen neck glands. The following symptoms or clinical findings are usually the first indications of neoplastic invasion of the nasopharynx and the occurrence of one or a combination should cause suspicion of the presence of such a lesion: (1) glandular swellings in the posterior cervical chain; (2) pain referred to the ear or throat; (3) unilateral deafness or a stuffy, full sensation in the ear; (4) changes in the tympanic membrane.

Treatment appears to be futile, only one of the 40 patients being alive at the expiration of two years.

W. R. BROOKSHER, M.D.

NEURALGIA

Roentgen Therapy of the Pain of Cervico-brachial Neuralgias. R. Gauducheau and J. Tardiveau. Bull. et mém. soc. de radiol. méd. de France, 26, 588, 589, October, 1938.

Cases of cervico-brachial neuralgia are usually seen at an earlier stage than those of sciatic neuralgia. Complete clinical and radiologic examinations are necessary to exclude organic lesions of the spine or shoulder joints in making this diagnosis.

The treatment is similar to that of sciatic neuralgia but usually smaller doses are given, the total dose for a séance varying from 50 to 200 r. The cervical field extends from the first cervical vertebra to the first thoracic, sometimes even higher or lower. The other fields are infraclavicular, scapular, over the arm, or over the forearm as indicated. Frequently the pain seems to be displaced distally in the course of treatment. The dose varies with the duration of the disease and its severity: early, painful, cases receive from 50 to 100 r at each visit. In the later cases, from 150 to 200 r may be given. Three to six treatments may be given in a series, the interval between varying from two to eight days. Infra-red may be employed before or during the treatments, high frequency currents and ultra-violet, during and after roentgen therapy. The roentgen technic: 130 kv., 6 mm. Al filtration, fields 8 to 10 cm. in diameter at 25 cm. F.S.D.

Of 30 cases, six were cured, 16 greatly relieved, two slightly relieved, three very slightly, and three not at all.

S. R. Beatty, M.D.

Roentgen Therapy of the Pain of Sciatic Neuralgia. R. Gauducheau and J. Tardiveau. Bull. et mém. soc. de radiol. méd. de France, 26, 585–587, October, 1938.

The authors present their method and results in the treatment of sciatic neuralgia. Those cases in which an organic basis was discovered are eliminated from their discussion

Radiologic examination was not always practised unless a first series of treatments failed to produce relief. The technic of treatment varied with the case. Precise localization of the level of origin of the affected nerves and points of peripheral involvement was considered essential. About half the total dose of from 200 to 300 r per séance was given over the involved spinal roots, the rest over the points of maximum pain. During the latter part of the treatment, only the peripheral fields were irradiated Treatments were given at intervals of from four to seven days, four to six treatments constituting a series. (Technic: 130 kv., filter 6 mm. Al, fields 10 cm. diameter, F.S.D. 25 cm.)

Of 56 cases, 15 were completely cured, 13 were greatly relieved, four had but slight relief immediately after treatment but were not followed. Ten cases had considerable immediate relief but were not seen again. Of seven cases with recurrence, two were greatly benefited by a second series. There were seven complete failures.

It must be remembered that these cases are usually seen very late by the roentgen therapist, after other methods of treatment have failed.

S. R. Beatty, M.D.

Treatment of Several Cases of Neuralgia of the Brachial Plexus. P. Kuentz. Bull. et mém. Soc. de radiol. méd. de France, 26, 479, 480, July, 1938.

Abandoning other methods of treatment, the author places reliance, in cases of brachial plexus neuralgia, in a combination of infra-red and roentgen irradiations. Infra-red exposures of from 20 to 30 minutes every other day are complemented by roentgen irradiation of the cervical region (100 r twice a week at first, then weekly, 80 kv., 2 mm. Al). Complete relief follows, usually in less than a month of treatment.

S. R. Beatty, M.D.

OSSIFICATION

Center of Ossification of the Coracoid Process in a New-born. Charles Varady. Bruxelles méd., 18, 1265, 1266, July 24, 1938.

One should not consider as absolutely certain the ages given for the appearance of centers of ossification, as occasional variations may give rise to legal difficulties. A case is presented in which the center of ossification for the coracoid processes of the scapulæ were present at birth, in a premature infant, as were those for the capitate and hamate bones of the wrist. This represents, as compared with the usual data, six months' advance in ossification.

S. R. Beatty, M.D.

An Unusual Ossification Center in the Pelvis. Gösta Lindberg. Acta Radiol., 19, 250–253, September, 1938.

A 15-year-old girl showed a bone shadow resembling an epiphysis over the antero-inferior aspect of the iliac crest. Several anatomists and roentgenologists have mentioned such an ossification center previously, without, however, definitely agreeing on its normal or pathologic significance. In Lindberg's case, there was no history of preceding trauma. A second x-ray examination after two and one-half months' lapse, failed to reveal any change in the radiologic appearance. The center may be unilateral and may possess differential diagnostic value.

Ernst A. Schmidt, M.D.

Complete Ossification of the Fibers of the Adduction Brevis. J. Moro and Monmignaut. Bull. et mém. Soc. Radiol. Méd de France, 26, 9, January, 1938.

A case of ossification of the adductor brevis, presumably following an injury 15 years previous, was brought to the authors' attention following a fall, with subsequent pain in the thigh. Curiously, al-

though the bony bridge between the pelvis and femur seemed complete there was limitation of movement only in abduction.

S. R. BEATTY, M.D.

THE PANCREAS

Regional Gastrospasm in Diseases of the Pancreas. Max Lüdin. Acta Radiol., 19, 348–351, October, 1938.

The author describes a case of prepyloric gastrospasm, apparently due to changes in the head of the pancreas (fibrous degeneration and hyperplasia) combined with atrophy of the excretory part and with pancreatic stones.

ERNST A. SCHMIDT, M.D.

Pancreatic Cysts: Report of Two Cases. Raymond M. Carmichael. Ohio St. Med. Jour., 35, 160–162, February, 1939.

In presenting two cases of pancreatic cyst, the author suggests the following classification:

1. Cysts resulting from defective development.
   (1) Cysts in infants.
   (2) "Polycystic disease of the pancreas" (dysontogenetic).
   (3) Lindau's disease.
   (4) Dermoid cysts.
   (5) Inclusion cysts.
2. Pseudocysts (cysts having no wall of their own, the wall being formed by peritoneal surfaces in the region of the pancreas).
   (1) Traumatic.
   (2) Inflammatory.
3. Retention cysts.
   (1) Calculi.
   (2) Annular scar formation.
4. Neoplastic cysts.
   (1) Cystadenoma.
   (2) Cystadenocarcinoma.
   (3) Teratomatous cysts.
5. Cysts resulting from parasites.

The dysontogenetic form, polycystic disease of the pancreas, is the rarest type and the pseudocysts are the most common. There is, as a rule, little disturbance of pancreatic function. The common complaint of the patient is usually the presence of a left-sided upper abdominal mass, which may, at times, be movable on respiration and palpation. The diagnosis is usually confirmed by the finding of a rounded extragastric and extracolonic mass causing extrinsic pressure from the posterior direction.

The first case presented was that of a 27-year-old white female, diagnosed pre-operatively as splenomegaly, but exploratory operation, in 1931, revealed the mass in the abdomen to be an enlarged cystic pancreas, which was resected. It proved to be of the dysontogenetic type. Subsequently, in 1933, she developed an acute intestinal obstruction due to adhesions, and a gangrenous loop of bowel was resected. After a stormy post-operative course, she recovered full health. However, in 1937, six years after the first operation, her symptoms and mass recurred. This time a correct pre-operative diagnosis of recurrence of the pancreatic tumor was made from observation of an extrinsic pressure defect on the posterior portion of the greater curvature of the stomach.

The other case, a white female, aged 29, was diagnosed by the observation of a rounded soft-tissue mass in the left upper quadrant of the flat plate of the abdomen. This finding was confirmed by surgery.

SIMON POLLACK, M.D.

PEPTIC ULCER

Perforated Peptic Ulcer: Its Differentiation from Acute Pancreatitis by Blood Diastase Determination. J. G. Probstein, P. A. Wheeler, and S. H. Gray. Jour. Lab. and Clinic. Med., 24, 449–452, February, 1939.

The authors made blood diastase determinations in 17 cases of acute perforated peptic ulcer, all of which came to operation or postmortem examination. They found the blood diastase to be normal or below normal in anterior perforated peptic ulcers, and moderately raised in posterior perforated ulcers near or at the pancreas, thus helping to differentiate perforated ulcers from acute pancreatitis in cases in which the diastase is very high.

W. A. WARD, M.D.

Peptic Ulcer of the Greater Curvature of the Stomach. F. S. P. van Buchem. British Jour. Radiol., 11, 667–670, October, 1938.

Peptic ulcer on the greater curvature is quite rare. The author reports one case found in a male, aged 24. He had a history of six months of gastric pain two hours after meals, relieved by food. Gastric contents showed no free hydrochloric acid in the fasting contents, the acid curve rose to 34 free and 55 total at the end of an hour. On screen examination, a large crater was seen exactly on the greater curvature. The stomach emptied in three hours, but a small residue remained in the crater. The Wassermann test was negative. The patient was operated upon. The histological examination showed a typical appearance of ulcer without any demonstrable evidence of cancer.

S. J. HAWLEY, M.D.

Carcinoma in Clinically Benign Gastric Ulcer. Max Mass and Frederick Steigmann. Illinois Med. Jour., 75, 120–122, February, 1939.

The authors give a full clinical history and thorough work-up of a case of a carcinomatous gastric ulcer which, until shortly before the death of the patient, presented, by all known diagnostic methods, all the so-called "typical" findings of a benign lesion. The patient was treated as for a benign ulcer; he responded favorably, and a decrease in size of the lesion was noted on x-ray examinations. A few weeks later, however, an autopsy examination proved the lesions to be a carcinomatous gastric ulcer and a duodenal ulcer. The authors call attention to the fallibility of the usual

diagnostic methods in attempting to distinguish between a benign and a malignant gastric lesion.

WILLIS A. WARD, M.D.

ROENTGEN-RAY THERAPY

Skin Reaction Following Roentgen Therapy in Areas of which the Innervation has been Injured. H. Bade. Strahlentherapie, **64**, 464, 1939.

The author searched the radiologic literature for some observations recording the effect of radiation in skin of which the innervation had been disturbed either centrally or peripherally, but could find no data on this subject. He therefore, reports a case of an individual who had a large inoperable retrobulbar tumor, apparently secondary to a carcinoma of the stomach. Radiation therapy was given in adequate doses but brought no relief from the severe pain. Therefore, the Gasserian ganglion was coagulated and a second time a week later, since the first coagulation did not bring relief. After the second operation, the third branch apparently ceased to function. Two weeks later the patient reported again and complained of numbness in the left side of the face. The pain had recurred. There was very little radiation reaction in the irradiated skin. Upon request of the patient, a second series was given about two months after the first series. However, after 4×250 r over the eye region and 5×250 r over the temporal-parietal field, irradiation had to be interrupted because of a very severe radiation reaction. Since this had not occurred before the coagulation of the ganglion and since a much smaller dose was given this time, the author believes that the increased radiosensitivity of the skin was due to the disturbance in innervation.

ERNST A. POHLE, M.D., Ph.D.

Posology of Anti-inflammatory X-ray Therapy: Statistics of 82 Cases. J. Huguet. Jour. de radiol. et d'électrol., **23**, 49–57, February, 1939.

The author emphasizes the use of weak doses of x-rays instead of strong doses in the treatment of inflammatory conditions. In the treatment of 29 furuncles, 26 were cured by x-ray alone, one was incised, and two died. In 14 cases of anthrax, there were no local failures but one death occurred one and one-half months later in a diabetic whose anthrax was practically healed. Most of the cases received 25 r or less, and a single treatment was usually sufficient but the condition of the patient determined whether or not repetition of the treatment was advisable. It is best to wait three days before repeating the treatment. The technical factors are 100 kv.p., 3 mm. aluminum, and 40 cm. distance. In late cases, x-ray therapy, especially with repeated doses, hastens the spontaneous opening of furuncles and the pus becomes more liquid and thus more easily evacuated.

Good results were also obtained in the x-ray treatment of seven cases of felon, three cases of adenitis (subacute or chronic), two breast abscesses, and two cases of bartholinitis. Fair results were obtained in the treatment of impetigo, parametritis, shingles, burns, and other miscellaneous conditions.

J. SAGEL, M.D.

THE SINUSES

Pertinent Facts Relating to Chronic Pansinusitis. William Mithoefer. Ann. Otol., Rhinol., and Laryngol., **48**, 158–164, March, 1939.

The author discusses the clinical aspects of chronic pansinusitis with special reference to diagnosis and methods of surgical treatment. Not all of the sinuses may be involved by the same type of inflammation, and complete removal of the diseased mucous membranes may not always be necessary in order to eradicate the disease. The importance of adequate examination of the ethmoid and sphenoid areas is stressed and, for this purpose, the author recommends infraction of the middle turbinate and displacement toward the septum, in order to obtain a better view of the floor of the ethmoid area.

Roentgenograms are of considerable aid in evaluating these cases, particularly when the disease is extensive. With mild degrees of clouding, as shown on the roentgenogram, it is more difficult to determine the significance of the changes from roentgen examination alone. Some of the surgical problems met with are discussed.

LESTER W. PAUL, M.D.

Malignant Tumors of the Nasopharynx and Paranasal Sinuses. N. S. Weinberger. Ann. Otol., Rhinol., and Laryngol., **48**, 203–211, March, 1939.

The general features of malignant tumors of the nasopharynx and paranasal sinuses are reviewed. It is generally accepted that, for malignant lesions in the nasopharynx, irradiation is the only method of treatment which may be expected to give results. For tumors originating in the sinuses, a combination of diathermic destruction followed by irradiation seems to be the preferable method. Three case reports are included, as typical of this group of cases.

LESTER W. PAUL, M.D.

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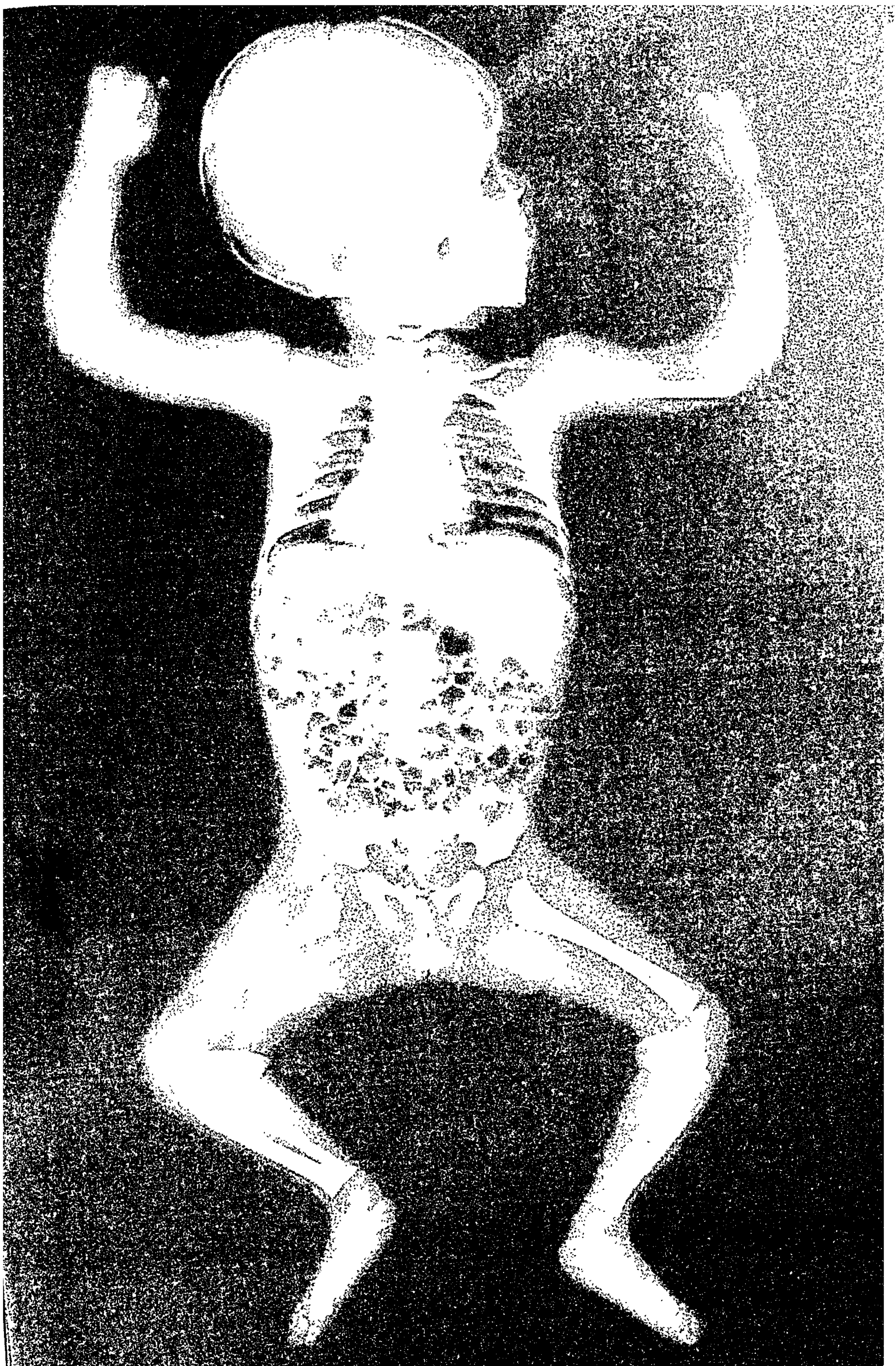

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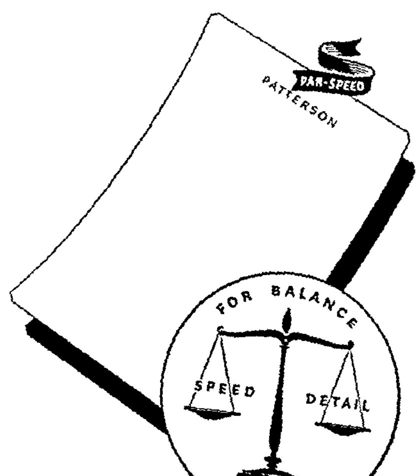

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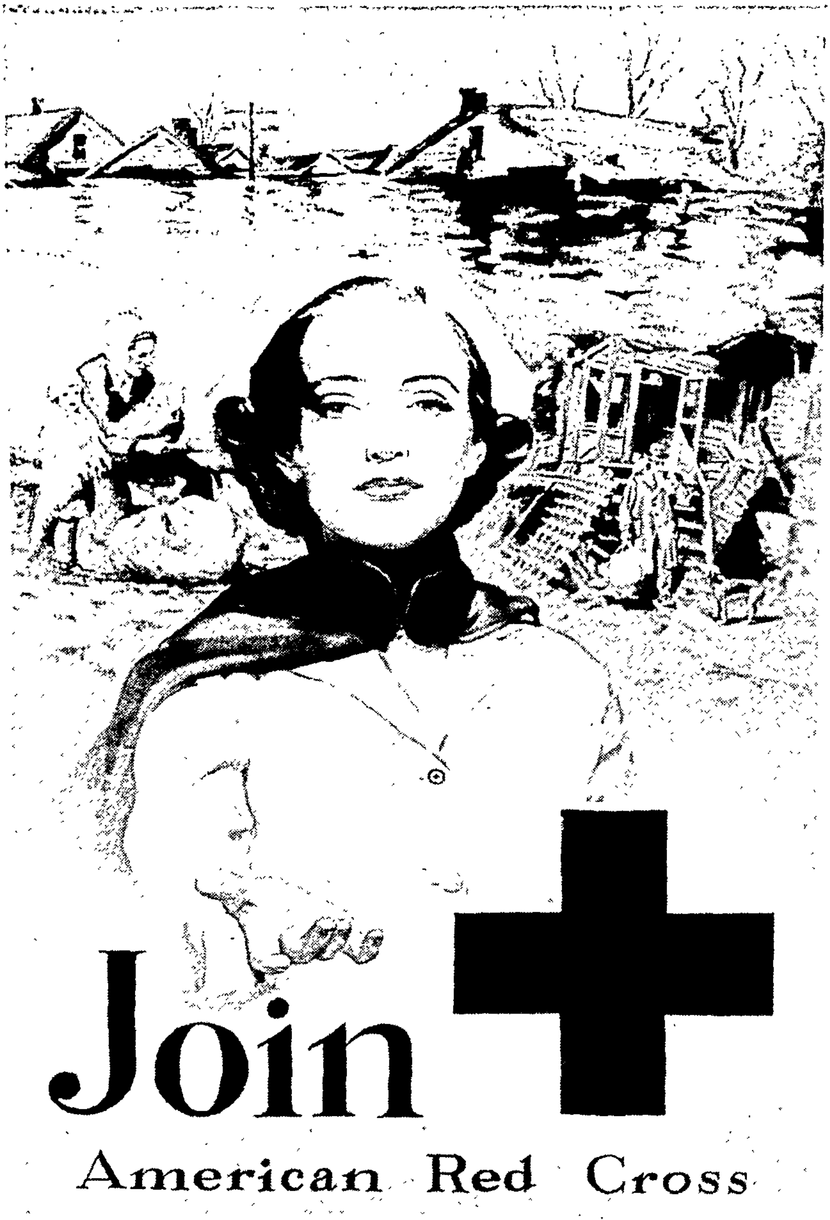
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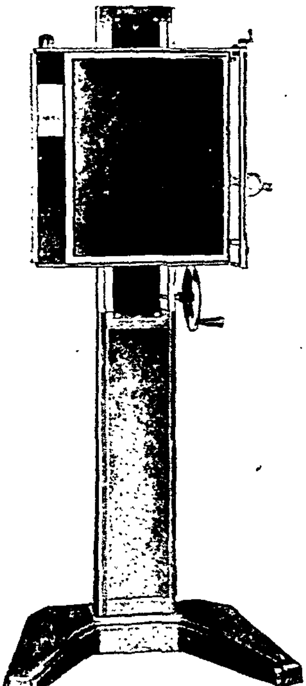

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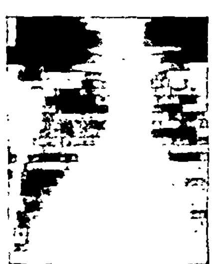

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